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VOL. CXLI.—No. 3659] LONDON: FRIDAY EVENING, FEBRUARY 12, 1926 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General, India Store Department Branch No. 15, Belvedere-road, Lambeth, S.E.1, invites TENDERS for—

40in. RAILWAY WHEEL LATHES.

Tenders due on the 26th February, 1926.
Tender forms obtainable from above. 1597

Assistant Engineer Re-QUIRED by the GOVERNMENT of the GOLD COAST for service with the Kumasi Public Health Board for two tours of 12 to 18 months' service, with possibility of permanency. Salary £480 a year, rising to £920 a year. Free quarters and passages and liberal leave on full salary. Outfit allowance of £60 on first appointment. Candidates should be between 25 and 35 years of age. Preference will be given to those who have had a training in the office of a corporate member of the Inst. C.E. and have passed the examination for A.M.I.C.E. or possess a degree in engineering recognised by the Inst. of C.E. as exempting from parts A and B of the A.M.I.C.E. examination, and have had some experience in an engineer's office and on works. Candidates possessing other engineering qualifications may apply. Should be able to ride a motor bicycle.—Application should be made at once by letter, stating age, qualifications, and particulars of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14,223. 1555

Calculator Required at the Royal Airship Works, Cardington, Bedford. Applicants must possess a university degree, either in Science or Engineering, and higher mathematics must have been one of the subjects taken in the degree examination.

Applicants must furnish evidence of experience in the stressing of complicated braced structures, gained preferably in connection with the design of aircraft.

Preference will be given to applicants who possess some knowledge of aerodynamics, and who can show experience in the manipulation of delicate instruments in connection with research work.

Applicants will be required to furnish evidence of ability to carry out long computations with a high degree of skill and accuracy.

Apply, giving full particulars and stating salary required, to the DIRECTOR of AIRSHIP DEVELOPMENT, Royal Airship Works, Cardington, Bedford. 1572

Test Assistants with technical training to the standard of B.Sc. degree in Pure and Applied Mathematics, Science or Engineering, REQUIRED in connection with the airworthiness approval of aircraft. Works and drawing-office training, and experience in aerodynamic or structural strength calculations or in the use of higher mathematics an advantage. Ex-Service men preferred. Salary 60s. plus Civil Service bonus, giving present total of 94s. 11d. p.w.—Write, quoting A. 91, to the SUPERINTENDENT, Royal Air Force Establishment, South Farnborough, Hants. 1563

INDIAN SERVICE OF ENGINEERS.

The Secretary of State for India in Council will in 1926 APPOINT NINE ASSISTANT EXECUTIVE ENGINEERS for this Service, including, if possible, ONE BURMAN, who will be appointed to the India-recruited branch in Burma.

Except for this one appointment, every candidate must be a European British subject.

Candidates must be not less than 21 years and not more than 24 years of age on 1st August, 1926.

They must either (1) have obtained one of certain recognised University Degrees or other distinctions in Engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers or been exempted by the Institution from such examination, or (3) produce the required evidence that they are otherwise eligible under the Regulations. They must in addition have had at least one full year's practical experience of Civil Engineering under a qualified Civil Engineer at the time when they appear before the Selection Committee.

Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W. 1.

India Office,
9th January, 1926. 1336

ARMSTRONG COLLEGE,
NEWCASTLE-UPON-TYNE
(In the University of Durham).

Courses for the Pass Degree of B.Sc. (3 years) and the Honours Degree of B.Sc. (4 years) in Mechanical, Marine, Civil or Electrical Engineering, Mining, Metallurgy or Naval Architecture. Composition (tuition) fee: £40 per annum.

Other Courses for Pure Science, Arts, Commerce, Law, Agriculture and Fine Art.

Full particulars on application to:

REGISTRAR,
Armstrong College,
Newcastle-upon-Tyne. 1175

Crystal Palace School of Practical Engineering,
Founded 1872.
MECHANICAL AND CIVIL ENGINEERING DIVISIONS.
PRESIDENT: J. W. WILSON, M.I.C.E., M.I.M.E.
PRINCIPAL: MAURICE WILSON, M.I.C.E.
Assisted by Staff of Lecturers and Instructors. Thorough, up-to-date Practical and Theoretical Instruction. Course completed in 2 years.
Students admitted at beginning of any term. 1174

The Engineer

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PUBLIC NOTICES

City of Birmingham Water DEPARTMENT.

The Water Committee of the Corporation of the City of Birmingham is prepared to receive TENDERS from competent firms for the MANUFACTURE and DELIVERY of SLUICE VALVES and IRONWORK in connection with their Bartley Reservoir now under construction.

Drawings may be inspected at the office of the Chief Engineer of the Water Department, Council House, Edmund-street, Birmingham, between the hours of 10 a.m. and 4 p.m. (10 a.m. and 12 noon, Saturdays).

Specifications and forms of Tender may be obtained from the Secretary of the Water Department, Council House, Birmingham, on payment of the sum of £1 1s., which amount will be refunded on receipt of a bona fide Tender.

Sealed Tenders, on the form provided for the purpose, addressed to "The Secretary, Water Department, Council House, Birmingham," and endorsed "Sluice Valves, &c., Contract 16," should be delivered at the Secretary's Office on or before 10 a.m. on Friday, 26th February, 1926.

The Water Committee does not bind itself to accept the lowest or any Tender.

F. W. MACAULAY, M. Inst. C.E.,
Chief Engineer.
J. H. BROADLEY,
Secretary.

Water Department,
Council House, Birmingham,
8th February, 1926. 1566

The South Indian Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY of—

1. CARRIAGE FITTINGS.
2. B.S. DISC WHEELS and AXLES (M.G.)

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Carriage Fittings," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 26th February, 1926.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of each specification.

Copies of the drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster.

W. B. REYNOLDS,
For Managing Director.

91, Petty France, S.W. 1.
10th February, 1926. 1602

PUBLIC NOTICES

Salford Union.
OLD PEOPLE'S HOMES, STOTT-LANE, PENDLETON.
HEATING, HOT WATER SUPPLY AND VENTILATION.

The Guardians are prepared to receive TENDERS for complete HEATING, HOT WATER SUPPLY and VENTILATING INSTALLATIONS at the above Institution.

Plans and specifications obtainable on application to Mr. Charles Swain, Architect, 12, Exchange-street, Manchester, on payment of a deposit of Three Guineas, which will be returned on the receipt of a bona fide Tender.

Tenders, endorsed "Heating, Installation, &c., Old People's Homes," on face of envelope, must be received by the undersigned not later than 10 a.m. on Saturday, 6th March, 1926.

The Guardians do not bind themselves to accept the lowest or any Tender.

By Order,
E. H. INCHLEY,
Clerk to the Guardians.

Poor Law Offices,
Eccles New-road, Salford.
8th February, 1926. 1564

Commissioners for the Port of Rangoon.

There are VACANCIES in the COMMISSIONERS' ENGINEERING STAFF for TWO ASSISTANT CIVIL ENGINEERS. Applicants should be unmarried, British subjects, between the ages of 25 and 30, who have received a good general education, preferably at a public school; are Chartered Civil Engineers who have passed the Associate Membership Examination of the Institution of Civil Engineers, and had not less than two years' practical experience on Port or Harbour Work since completion of their indentures or equivalent training.

The engagement in the first instance will be for three years, but it is possible that at the end of that term the persons appointed would, if suitable, be placed on the permanent establishment should vacancies occur.

The salaries of the appointments are Rs. 700, rising by annual increments of Rs. 40 to Rs. 900 per mensem, with a motor cycle allowance of Rs. 50 per mensem; the increments are subject to passing the Government examination in Colloquial Hindustani, and conduct and work being reported as satisfactory. In the event of Port Commissioners' quarters being available, and occupied by an Assistant Engineer, rental of 7½ per cent. of salary will be payable.

The officers appointed will be provided with free first-class passages to Rangoon, and £10 each for expenses on the voyage. Should they, on the termination of their agreement, elect to return to England, they will be granted the same concession.

Applications, in writing, giving a full statement in chronological order, of education and experience, should be addressed, not later than the 1st day of March, 1926, to J. LUMSDEN RAE, Esq., Dartmouth House, 2, Queen Anne's-gate, Westminster, S.W.1. 1600

PUBLIC NOTICES

Inspector-General of Irrigation, SUDAN.

With reference to my invitation for TENDERS which appeared in the issue of this Journal dated December 25th, 1925, for the SUPPLY of various kinds of MATERIALS for the Equipment of the Irrigation Dockyard at Rabak, near Kosti, on the White Nile, Sudan.

NOTICE IS HEREBY GIVEN that the ENQUIRY for the complete SCHEME is POSTPONED.

A further notice will be published in this Journal when the enquiry is reopened. 1554

Skegness Urban District Council.
REINFORCED CONCRETE WATER TOWER.

The Council invite TENDERS for the CONSTRUCTION of a REINFORCED CONCRETE WATER TOWER at Skegness, in the County of Lincoln, adjoining the Council's existing Pumping Station, about one mile from the Railway Station, Skegness.

The work includes the Building of a Reinforced Concrete Water Tower complete, with 10in. Service Mains, Valves, Access Ladders, Galleries, Water Level Indicator, &c.

The contractor must conform to the conditions required by the Council.

Copies of the conditions, specifications, bill of quantities, plans, and form of Tender prepared on behalf of the Council by their Consulting Engineer, Percy Griffith, Esq., M. Inst. C.E., M.I. Mech. E., F.G.S., may be obtained on application to the Reinforced Concrete Specialists, Messrs. Walter Bridges and Co., of 57, Parliament-street, Westminster, S.W. 1, on or after Friday, February 12th, 1926.

The application must be accompanied by a deposit of £5, which will be refunded on return of the documents within seven days, or after the receipt of a bona fide Tender and the documents required.

Facilities for examining further drawings may be obtained on application to Messrs. Walter Bridges and Co., and inspection of the site can be arranged on application to Mr. E. H. Jenkins, Surveyor, Council Offices, Skegness.

Tenders are to be sent in on the form supplied, and with the annexed documents must be enclosed under a sealed cover, endorsed "Tender for Construction of Water Tower, Skegness Waterworks," addressed to and reaching the undersigned not later than 10 a.m. on Friday, February 26th, 1926.

The Council do not bind themselves to accept the lowest or any Tender.

W. FREARSON,
Clerk to the Council.

Council Offices, Skegness,
28th January, 1926. 1569

Sudan Government Railways REQUIRE the SERVICES of a DISTRICT ENGINEER (Civil). Age 26 to 32, preferably single. Candidate should possess A.M.I.C.E. degree or equivalent, and should have had practical experience in railway construction and maintenance as Civil Engineer on a British Railway. Starting rate of pay £480 to £540, according to age and qualifications. Progressive post if retained. Strict medical examination. Free first-class passage. Liberal leave.—Apply by letter to ADVISORY ENGINEER, Sudan Government London Office, Wellington House, Buckingham Gate, S.W. 1, marking envelope "District Engineer." 1574

The Town Board of Belize, British Honduras, Central America, is DESIROUS of OBTAINING the SERVICES of a qualified CIVIL ENGINEER to undertake the duties of Town Engineer, the appointment of the officer having been sanctioned by the Government as from April 1st next.

Particulars of the appointment can be obtained by application in writing only to Messrs. HOWARD HUMPHREYS and SONS, Consulting Engineers herein to the Government of British Honduras and Town Board of Belize, 28, Victoria-street, Westminster, S.W. 1587

SITUATIONS OPEN

WANTED, an ENGINEER Capable of Taking Charge of old-established Engineering and Ironfounders' Business in West of England, including Works Control, Estimating and Correspondence.—Address, with particulars, 1593, The Engineer Office. 1593 A

WANTED, an Up-to-date MAN to Take Up Time Studies for Engineering Productions. Must be thoroughly conversant with Modern Machine and Assembly Shop Methods and Appliances and capable of demonstrating his own times. State fully experience, age, salary expected and when free.—Write, "TIME," c/o Dixon's, 195, Oxford-street, W. 1. P1543 A

WANTED for Birmingham, ENGINEER REPRESENTATIVE. Knowledge of Pneumatic Tools and Plant essential.—Address age and full particulars of training, experience, salary required, together with references, 1575, The Engineer Office. 1575 A

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WANTED, Thoroughly Qualified ENGINEER with experience in Furnace Design and preferably with some commercial experience. Manchester area. State full particulars of qualifications and salary expected.—Address, 1559, The Engineer Office. 1559 A

ASSISTANT REQUIRED for Design and Estimating Department of London Constructional Engineers. Similar experience essential, also thorough knowledge of London Building Acts.—Address full particulars, age, 1557, The Engineer Office. 1557 A

CHIEF MECHANICAL ENGINEER REQUIRED for large Cement Works. Applicants must be thoroughly conversant with Steam Turbines, Babcock and Lancashire Boilers, Steam Excavators, Cyclone Drills, Stone Crushers, all kinds of Elevating and Conveying Plant, and Mill Gearing. Good organiser and capable of handling men. Preference given to one with previous cement works experience.—Address, 1558, The Engineer Office. 1558 A

ESTIMATOR REQUIRED IMMEDIATELY for works near London; used to Pressure Vessels, Riveted and Welded; also Sheet Metal Work.—Address, 1595, The Engineer Office. 1595 A

EXPERIENCED ACCOUNTANT REQUIRED by large Engineering and Manufacturing Firm in the North of England, to Take Charge of all Accounts relating to finance, including branches at home and abroad, and to Organise and Control the Costing Departments. Must have had good practical experience in similar situation, be thoroughly conversant with modern systems of costing and capable of controlling all general office arrangements and large staff. —Apply by letter only, stating age, full particulars of experience, references, and salary required, to Messrs. SHUTTLEWORTH and HAWORTH, Chartered Accountants, Lloyd Bank Buildings, King-street, Manchester. P1561 A

MECHANICAL GOODS SALESMAN REQUIRED IMMEDIATELY by large Rubber Manufacturers. Only first-class man with previous experience in North of England need apply. Must have thorough knowledge of local industries. Liberal salary and expenses.—Address, giving age and full information, 1567, The Engineer Office. 1567 A

THE POSITION of ENGINEER Under Box No. 1413 is now FILLED. The Advertisers wish to express their thanks to all applicants. P1541 A

WANTED by Large Manufacturing Firm in the West, a TEMPORARY DRAUGHTSMAN with good general experience.—Address, giving full particulars and salary required, 1580, The Engineer Office. 1580 A

WANTED IMMEDIATELY, a FIRST-CLASS DRAUGHTSMAN: Design of Heavy Machinery and Structural Steelwork: must have good experience and references: London area. Good salary to good man.—Address, 1599, The Engineer Office. 1599 A

DRAUGHTSMAN, Age About 35, Accustomed to Estimating and Valuing, and in a position to commence duties at once; must be quick and accurate.—Address, 1594, The Engineer Office. 1594 A

DRAUGHTSMEN.—BEFORE NEGOTIATING with Government Departments in connection with any post, PLEASE COMMUNICATE with the GENERAL SECRETARY, Association of Engineering and Ship building Draughtsmen, 98, St. George's-square, London, S.W. 1. 1169 A

DRAUGHTSMAN, JUNIOR, Also IMPROVER, for Constructional Engineers, London; local applicants; prev. exp. essential. State wages and exp.—Address, P1568, The Engineer Office. P1568 A

DRAUGHTSMAN (SENIOR) WANTED for Constructional Steel Work. Well accustomed to the full routine of a Constructional Engineer's Estimating and Order Office. Well up in calculations and stresses. Say when disengaged, wages required, age, and fullest particulars.—Address, 1581, The Engineer Office. 1581 A

DRAUGHTSMAN WANTED for Experimental Work. Active and able to grasp ideas. Aircraft and Automobile Body Work experience preferred.—Write, stating age and salary required, to Box 211, T. B. Browne's Advertising Offices, 163, Queen Victoria-street, E.C. 4. 1548 A

WANTED, SENIOR DRAUGHTSMAN, with Experience of High Vacuum Condensing Plant; age not less than 30. Recent experience with leading firm of condenser makers essential. Permanent position for suitable first-class man; Manchester district. —Address, stating age, experience, and salary required, 1582, The Engineer Office. 1582 A

CONSTRUCTIONAL DRAUGHTSMAN.—East Coast STEEL WORKS REQUIRE the SERVICES of an energetic MAN with sound theoretical knowledge and practical experience in all classes of Constructional Work.—Address, stating age, qualifications, and salary required, 1583, The Engineer Office. 1583 A

MACHINE TOOLS.—Competent All-round MACHINE TOOL DRAUGHTSMAN, also JIG and TOOL DRAUGHTSMAN, for works in West Riding (Yorks.). Applications to state fully experience, age, wages, &c., in confidence.—Address, 1577, The Engineer Office. 1577 A

FOREMAN REQUIRED for Fitting and Assembling Dept., Light and Medium Machinery. Only first-class men need apply. State full experience, age, salary.—Address, 1578, The Engineer Office. 1578 A

MACHINE SHOP FOREMAN WANTED, to Take Charge of Machine Shop in small engineering works in South of England. Must be a live man with organising ability, experience of modern methods of production essential. Preference will be given to one having experience in the manufacture of Internal Combustion Engines.—Address, with full particulars, P15.0, The Engineer Office. P1550 A

MESSRS. D. NAPIER and SON Have VACANCIES for a limited number of APPRENTICES, and are prepared to receive APPLICATIONS from the parents of well-educated youths who are not more than 16 years of age for an indentured apprenticeship covering a period of five years.—Apply by letter to 211, The Vale, Acton, W. 3. 1579 A

SITUATIONS WANTED

A SPANISH and PORTUGUESE-SPEAKING British ENGINEER, with first-class credentials, proved ADMINISTRATIVE ABILITY and energy, with wide technical and commercial experience as Loco. Supt., Chief Engineer, Traffic and Assistant General Manager important railways, recently Director and General Manager of large Engineering, Transportation, Construction and Industrial Company, now closing down, OFFERS SERVICES in SIMILAR CAPACITY, preferably abroad.—R. GODFREY-ASTON (Lt.-Col.), Windyholme, Summerhill, Chislehurst. 1598 B

CIVIL ENGINEER (40), University Degrees, 17 years' experience, home and abroad, in railways, surveys, irrigation and building construction, DESIRES POST similar capacity. Excellent references. Willing to go abroad.—Address, P1559, The Engineer Office. P1559 B

SITUATIONS WANTED (continued)

CONSTRUCTIONAL ENGINEER (38), M.I. Struct. E., OPEN for immediate ENGAGEMENT in responsible capacity at home or abroad. Considerable experience in steel and reinforced concrete construction for large variety of work. Recently returned from Far East, where solely responsible for design and construction of complete structures for numerous large buildings.—Address, P1546, The Engineer Office. P1546 B

COST ACCOUNTANT, Trained Organiser, with varied experience in engineering, iron and steel, rolled metals, foundry, &c., DESIRES POST in Midlands entailing full charge and immediate responsibility to directors. Address, P1465, The Engineer Office. P1465 B

ENGINEER, A.M.I.E.E. and M.I.P.E., Very Wide experience, practical and technical, SEEKS POST as WORKS MANAGER. University education. —Address, P1549, The Engineer Office. P1549 B

ENGINEER, A.M.I. Mech. E. (36), Practical and commercial, DESIRES CHANGE as General Manager with large firm. Had extensive experience in successfully managing works. Communications are solicited from firms requiring the services of a conscientious man with the necessary qualifications for above post.—Address, P1560, The Engineer Office. P1560 B

CRANES, CONVEYORS, EXCAVATING MACHINERY.

ENGINEER MANAGER (40), Twenty Years' Proved exp. all branches, designing sales, manufacture, &c. pub. sch., French, Spanish, at liberty.—ENGINEER, Rumsey Garage, Rumsey-road, Stockwell, London. P1569 B

ENGINEER (30), 5 Years' Appron. Maintenance, 10 years' sea experience in one employ, 1st class B. of T. certificate, SEEKS POSITION, not abroad. —Write, W. O'SHEA, 21, Ceylon-street, London, S.W. 8. 1563 B

ENGINEER (37) DESIRES CHANGE. At Present in sole charge of generating plant (high superheated steam) and plant maintenance. Practical experience with oil (cold-starting), gas and steam engines, pumps and general millwright, also drawing-office, for several years outside engineer at home and abroad. —Further particulars, Box 2393, W. H. Smith and Son, Strand House, London, W.C. 2. P1542 B

ENGINEER (37) DESIRES POST, Home or Abroad; experience in construction of and running stern-wheel steamers, erecting all kinds of engines, boilers and machinery, including cotton and rubber hydraulic cranes, &c.; excellent testimonials.—F. BERRY, 22, Canadian-avenue, Catford, S.E. 6. 1596 B

FLETCHER, Founder and Late Man. Dir. North Bridge Construction Co., York, Struct. Engrs. and Roof Glaziers, DESIRES ADMIN. POST; would consider Partnership small structural works.—Apply, Mill Hill, Huntington, York. P1564 B

MACHINE SHOP SUPERINTENDENT or PRODUCTION ENGINEER, thoroughly experienced, good organiser, able to get maximum output, up-to-date methods of mass production; highest references of proved ability.—Address, P1562, The Engineer Office. P1562 B

MECHANICAL ENGINEER, Age 36, SEEKS CHANGE; 19 years' practical and technical experience, fully capable of taking charge of large steam plant and machinery or installation; 12 years' practical experience in up-to-date plants in U.S.A. and Canada; guarantee high efficiency. Good references.—Address, P1520, The Engineer Office. P1520 B

MECHANICAL ENGINEER (42), Experience as manager of general engineering works, including pattern shop, smithy, foundry, machine shop and boiler shop, used to correspondence, estimating, travelling and all office routine, REQUIRES ENGAGEMENT.—Address, P1530, The Engineer Office, P1530 B

MECH. ENGINEER, G.I. Mech. E., Mech. Eng. Dipl., A.M.I.L.E., SEEKS POST with prospects, Midlands or South pref.; 5 years shops, 3 years eng. coll., 2½ years D.O.—Address, P1532, The Engineer Office. P1532 B

MECHANICAL ENGINEER, Shop and Sea Experience, Extra 1st Class B.O.T. Certificate. Late 26 years chief to large London business house. Experienced in steam, electrical, hydraulic, and refrigerating plant, &c. London preferred, but not essential.—Address, P1547, The Engineer Office. P1547 B

NAVAL ARCHITECT, B.Sc. (Glas.), A.M.I.N.A. (28), DESIRES APPOINTMENT, home or Continent; 12 years' D.O. and yard exp., design and construction large passenger and cargo vessels; 1st cl. refs.—Address, P1555, The Engineer Office. P1555 B

PUBLIC SCHOOL MAN (24), Perfectly Trained in constructional engineering works, DESIRES POSITION, Assistant Works Manager or Supervisor, home or abroad.—Address, P1554, The Engineer Office. P1554 B

TO ARTIFICIAL SILK MANUFACTURERS.—Young TEXTILE ENGINEER (experience with large firm), with advanced and up-to-date practical experience in the process, design and layout of machinery for the production of ARTIFICIAL SILK, LABORATORY EXPERIENCE, and capable of incorporating ideas, DESIRES POST in any capacity where his experience would be useful.—Address, P1551, The Engineer Office. P1551 B

SITUATIONS WANTED (continued)

DRAUGHTSMAN (Senior), Experienced Engineer, fully conversant with up-to-date methods of production, SEEKS CHANGE. Responsible and progressive position required.—Address, P1552, The Engineer Office. P1552 B

ENGINEER'S DRAUGHTSMAN (22) SEEKS Progressive POSITION; 4½ yrs. workshop and D.O. exp. with large gen. engineers and founders. Excellent refs.—Address, P1556, The Engineer Office. P1556 B

HEAD FOREMAN BOILERMAKER, Fully Experienced in every class of boilermaking, constructional work, &c., labour-saving tools, organising, piece-work.—Address, P1565, The Engineer Office. P1565 B

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AN Opportunity Occurs for the INVESTMENT of about £750 to £1000, part debentures and part ordinary shares, in recently reorganised Engineering Company in Sheffield (Colliery Supplies); position may be found for suitable Investor.—Full particulars address, P1558, The Engineer Office. P1558 C

ENGINEER and CONTRACTOR, with a Valuable new Master Patent, and good orders in hand, and having old-established connections with colonial and Native State Governments, REQUIRES a FINANCIAL PARTNER. Will offer a Royalty of 10 per cent. on the net selling price of every machine sold, plus 10 per cent. net profit p.a. References exchanged. Particulars to principals or solicitors at interview only. No agents.—Address, 1601, The Engineer Office. 1601 C

EDUCATIONAL

CORRESPONDENCE COURSES for Inst. C.E., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS, personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Eng., London, Assoc. M. Inst. C.E., Chartered Civil Engineer, M.R.S.T., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successes. Course may commence at any time.—Apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), A.M.I.C.E., &c., 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN-STREET, LIVERPOOL. Telephone No. 1118 Bank. Ex. B

COACHING in CIVIL ENGINEERING SUBJECTS. —To G. W. M. BOYCOTT, Assoc. M. Inst. C.E., Chandos House, Palmer-street, Westminster, S.W. 1. 1486 B

PITMAN'S POSTAL COURSE IN ENGINEERING DRAWING.—To succeed in any branch of Engineering, you must have a knowledge of Mechanical Draughting and Machine Design. The specialised course, first established in 1894, teaches you the very latest and most modern drawing office practice, and is specially arranged for those who are working in the daytime or preparing for examinations. Whether you intend to go in for Mechanical, Civil, Electrical, Hydraulic, or Motor Engineering, &c., you will find the system of teaching of the utmost value. Many students have found it the "Open Sesame" to a profitable career. If you are not satisfied with your present occupation ENROL NOW for the complete course. Day or evening tuition can also be arranged. PITMAN'S, 25, Victoria-street, London, S.W. 1.

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(Hons. Oxon & Lond.),

14, Elsham Road, Kensington, London, W. 14

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FOR HIRE, PUMPS and WELL-BORING TOOLS for Contractors' Deep Wells, &c., 2in. to 24in dia.—E. RICHARDS and CO., Upper Ground-street, London, S.E. Telephone No. 978 Hop. 822 E

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THE PROPRIETOR of BRITISH PATENT No. 190,665, dated February 14, 1922, relating to "Improvements in and relating to Means for the Automatic Control of Furnace Dampers and the like," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to B. SINGER, 26, East Jackson Blvd., Chicago, Illinois. 1524 H

THE PROPRIETORS of LETTERS PATENT No. 122,427, relating to "Improvements in Propellers," DESIRE to DISPOSE of their PATENT or to GRANT LICENCES to interested parties on reasonable terms for the purpose of EXPLOITING the above and ensuring its full commercial development and practical working in this country.—Enquiries to be addressed to CRUIKSHANK and FAIRWEATHER, Chartered Patent Agents, 69-66, Chancery-lane, W.C. 2. 1523 H

THE PROPRIETOR of BRITISH PATENTS Nos. 165,167 and 183,906, both dated April 27, 1921, relating to "Improvements in Disk Steel Wheels" and "Improvements in Disk Wheels," respectively, is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patents and ensuring their practical working in Great Britain.—All inquiries to B. SINGER, Steger Building, Chicago, Ill. 1537 H

THE PROPRIETOR of BRITISH PATENT No. 180,279, dated March 8, 1919, relating to "Safety Devices for Forcing Machines and the like," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to B. SINGER, 26, East Jackson Blvd., Chicago, Illinois. 1535 H

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For continuation of Small Advertisements see page 3.

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A Seven-Day Journal

Public Works in Spain.

AN effort to make up for the transport deficiencies in Spain is observable in the proposal which has been approved by the Government to grant a concession to an Anglo-American group for carrying out a programme of public works which will be extended over a period of twenty-five years. The plans comprise the construction of about 1100 miles of railway, a circuit of roads for motor vehicles, and the deepening of the Guadalquivir to render it navigable from Andujar and the dredging of the Ebro from Caspe. Among the first railways to be constructed are the Orense-Zamora, Caspe-Lerida, Cuenca-Mial and Madrid—Burgos *vid* Aranda. All these undertakings will be carried out and exploited by the Anglo-American group during the period stated with the aid of capital which it will be authorised to raise with the guarantee of the State, which guarantee will be provided by the credits voted for the maintenance of public works. This awakening of Spain to the necessity of improving her existing inadequate transport facilities would seem to promise some contribution to the revival of British industrial activity.

A Transatlantic Air Line.

THE successful flight of the three Spanish airmen from Spain to South America, although protracted by minor accidents, appears to have served the purpose intended of stimulating public interest in the projects for creating regular air services between Seville and Buenos Aires. The seaplane used for the flight was of German construction, and the promoters of the venture were the members of a Spanish-German syndicate, who are seeking to obtain concessions for services to be operated with airships and aeroplanes. One of the schemes which the Syndicate has in view is that of Dr. Eckener for running a number of Zeppelins, while the Junker Company proposes to carry on a service by means of huge all-metal aeroplanes with five propellers and capable of carrying, so it is said, a hundred passengers. The journey between Seville and Buenos Aires would be made in three days by using as stopping places the Canary Islands, Cape Verde Islands or St. Paul's Island. The Zeppelins would, of course, accomplish the journey in one flight, but in view of the storms often encountered in the Southern Atlantic, it is considered doubtful whether airships could be relied upon, while the huge Junker aeroplanes have yet to be built and tested. Much encouragement is forthcoming in Spain and Argentina for the schemes, but their realisation appears to lie in the distant future.

Motor Vehicle Repairers.

THE Council of the Institution of Automobile Engineers has during recent years repeatedly had its attention directed to the shortage of men really competent to carry out repairs to motor vehicles. With the increasing number of such vehicles in service, this shortage, it is believed, will become more and more apparent as time goes on. The Council believes that the future can only be satisfactorily provided for if, as soon as possible, some scheme is put into operation for the training of lads specifically as repairers as distinct from training them for positions in manufacturing shops. The satisfactory conduct of repairs, at least in small establishments, calls for great versatility on the part of the repairers. Only in large depôts is it practicable to employ men who are specialists in particular work. The Council has circularised all the motor manufacturers and leading garage proprietors with a view to discovering general opinion on the subject. With the latter it has enclosed a schedule suggesting a scheme of training for automobile repair men. The schedule proposes a five year's period of training in the works of a manufacturer, at the end of which a written and practical examination would be held, the results of which would decide whether the candidate would be entitled or not to call himself a "certified automobile repair man." It is suggested that of the five years' training 9½ months should be spent in the machine shop, three months on fitting and assembling, three months on electrical equipment, four months on engine and car testing, four months between the view room, the tool store, wheel and tire work and copper smithing, a fortnight on hardening and welding, and three years on repairs. In addition, a syllabus of book work is suggested.

New Cruisers to be Launched.

LAUNCHING dates have now been assigned for four out of the five cruisers which were begun under the Navy Estimates of 1923–24. The Suffolk, which was laid down at Portsmouth on September 30th, 1924, is to go afloat on February 16th, the naming ceremony being performed by the Marchioness of Bristol. The First Lord of the Admiralty, and his colleagues on the Board, who will be making their official visit of inspection at that date, are expected to be present. The Cornwall, begun at Devonport on October 9th, 1924, will take the water on March 11th, the sponsor being Lady Clinton. The Kent, the keel of which was laid at Chatham in November, 1924, is to be launched on March 16th, and on the same day her sister vessel, the Cumberland, which has been under construction at the Vickers yard, Barrow-in-Furness, since October, 1924, will also go afloat. No date has yet been announced for the launch of the fifth ship, the Berwick, which was laid down in the Fairfield yard at Govan during November, 1924. Preparations are being made at Portsmouth and Devonport respectively to place in position the keel-plate of a new cruiser as soon as the berths are vacated. All the five vessels named belong to the new "County" class, the tonnage and displacement of which are governed by the Washington Treaty. Nothing is known of their design except that it involves a displacement of 10,000 tons—without fuel or feed-water—and an armament of 8in. guns. Six more cruisers of 10,000 tons and one of 8000 tons are due to be laid down before the end of the coming financial year.

New Orders for the North-East Coast.

CLOSELY following our journal note of last week regarding the new shipbuilding orders for the Clyde, comes the welcome announcement that four large motor ships are to be constructed on the North-East Coast. The success of the two motor vessels, Port Hobart and Port Dunedin, of the Commonwealth and Dominion Line, Ltd., has induced that line to place with Swan, Hunter and Wigham Richardson, Ltd., orders for two 475ft. cargo ships of 8000 tons gross and about 11,600 tons deadweight carrying capacity. One of the ships will be engined with Doxford motors, whilst the other will be fitted with Sulzer engines, which are to be built by the Wallsend Slipway and Engineering Company, Ltd. We are also given to understand that a third vessel will be ordered, which will also be engined by William Doxford and Sons, Ltd., of Sunderland. The new ships should be in service by the summer of 1927. The Furness Shipbuilding Company, Ltd., of Haverton Hill-on-Tees, is to build for the New York–Chile service of the Grace Line two 10,600-ton twin-screw motor passenger liners with a designed speed of about 17 knots. The engines will be of the Sulzer type with twin machinery designed for a total output of about 10,000 indicated horse-power. The ships will be the most powerful motor liners which have yet been designed in England for owners abroad. This order was obtained, we learn, in the face of keen foreign competition.

The Royal Indian Navy.

ON Tuesday it was announced at Delhi and in London that it had been officially decided to reconstruct the Royal Indian Marine as a combatant force, with the object of enabling India ultimately to undertake her own naval defence. The service will be known as the Royal Indian Navy, and will fly the White Ensign. During peace time the functions of the service will be to train *personnel* for war service; to carry out the work required by the Indian Government in the Indian Ocean and the Persian Gulf, to organise the naval defences at ports under the control of the Indian Government, to carry on survey work in the Indian Ocean, and to conduct transport services for the Indian Government. To begin with, the fleet will consist of four sloops, two patrol vessels, four trawlers, two survey ships, and one depôt ship. Indians are to be eligible for commission in the service. The policy underlying the scheme is in keeping with that pursued in connection with the naval defence of the Dominions, and will eventually bring India into line with Canada, Australia, New Zealand and South Africa in the matter of providing its own forces for the defence of its coast line and sea-borne commerce. For a long time India possessed a fighting navy under the old East India Company, but after the Mutiny, on the score of economy, the navy was abolished and in its place the Indian Marine, primarily a non-combatant force under British officers, was established. The British Admiralty since that date has undertaken the naval protection of India, and in return India has contributed £100,000 a year to the general naval expenditure of Great Britain. That grant will now presumably cease, but in its place there will be certain economies that should, it is believed, more than compensate the British Treasury.

A Notable Trial Trip.

ON Saturday last, the 6th inst., the official trials of the motor passenger liner Asturias took place outside Belfast Loch, after which the vessel proceeded to Southampton with a large number of representatives of shipping, shipbuilding and engineering interests on board. The new vessel, which has a measurement of 22,500 gross tons, was built and engined by Harland and Wolff, Ltd., Belfast, for the Royal Mail Steam Packet Company, and is engined with Harland-B. and W. type twin-screw four-cycle double-acting motors. Each engine has eight cylinders, 840 mm. diameter and 1500 mm. stroke, and the two units are designed for a total output of 20,000 indicated horse-power, at a normal speed of 115 revolutions per minute. The main air compressors are fitted at the forward end of each engine, and power for all auxiliaries is provided by four 400-kilowatt Diesel electric generator sets. The machinery installation is the largest of its type in service, and considerable interest attaches therefore to its performance. We had the pleasure of being present at the trials, and can congratulate both the builders and the owners on their complete success and on that of the run from Belfast to Southampton. Both the main engines and the auxiliaries performed their duties without incident, and with a general freedom from vibration which was the subject of very favourable comment. The Asturias berthed at Southampton on Monday morning, when again the excellent manœuvring qualities of her engines were amply demonstrated. A short reference may be made to the results of the preliminary trials. During a forty-eight hours' run on the Skelmorlie mile progressive trials at from 92 to 122 engine revolutions were made, and at the higher speed an output of well over 23,000 indicated horse-power was registered. When opened up after the trials—which were equivalent to a run of about 1400 miles—the engines were found to be in first-class order. The fuel consumption worked out at about 70 tons per day of twenty-four hours for all purposes at full service power. The Asturias is due to leave Southampton for the River Plate on Friday, the 26th inst.

A Large Marine Wireless Installation.

THE Asturias, it is worthy of note, has been equipped by the Marconi International Marine Communication Company with one of the most complete wireless installations carried by any ship afloat. The main wireless telegraph installation consists of a quenched spark transmitter with emergency apparatus, and a long range valve transmitter, which will enable the ship to keep in constant communication with land stations and other vessels throughout every voyage. The receiving equipment consists of a standard long range receiver embodying a four-electrode valve amplifier with the addition of an extra high-frequency amplifier, which makes the tuning extremely sensitive and very selective. Marconi direction finding equipment of the latest type has been installed to aid navigation. Two of the life-boats also carry Marconi wireless apparatus. The transmitters on these boats are of the quenched spark type rated at a ¼-kilowatt, and the power is obtained from petrol engine driven generators. A Marconi band repeater, similar to that shown at the recent Shipping, Engineering and Machinery Exhibition, has also been installed in the Asturias, and by means of six loud speakers music played by the ship's orchestra or reproduced from a gramophone, or received by wireless, may be reproduced in any part of the vessel.

Highway Engineering.

THE Paviors' Company is continuing its efforts to secure the establishment of a Chair of Highway Engineering at London University. At the annual dinner on Monday the Master stated that the bare cost of endowing the proposed Chair was estimated at £30,000, towards which some £10,000 had been subscribed or promised. The assistance of highway authorities, engineers, surveyors, the transport industry and others was being sought to enable the required sum to be completed. It was intended that the proposed course in highway engineering should be a post-graduate one, covering a period of three years, and that those students who succeeded in passing the final examination should receive the degree of B.Sc. Highway Engineering. So great has been the demand for membership of the Company, consequent upon its interest in this scheme, that it has presented a petition to the Court of Aldermen praying for permission to increase the livery of the guild from the present statutory maximum of 100 to double that number.

New Superintendent-Engineer, P. and O. Line.

IT is announced that Mr. R. T. Clarke has been appointed superintendent-engineer to the P. and O. Line in London. Mr. Clarke was educated at Sheffield, and in 1882 began his training as an engineer in the drawing-office of John Brown and Co., Ltd., in that city. Subsequently, he passed to the shops, and then to outside erecting work. In 1889 he joined the P. and O. Company's steamer Valetta as sixth engineer, and until 1912 continued in the company's service as a sea-going engineer. For seven years of that period he acted as chief engineer on several of the company's principal vessels. In 1912 he was appointed superintendent-engineer of the company's steamship services and workshops in Bombay, and in 1919 he received the post of superintending the construction of the machinery of the P. and O. vessels built on the Wear, Humber, Tyne and Clyde. From that position he has now been advanced to the post mentioned in our opening sentence. Mr. Clarke is keenly interested in motor ships, and is said to have attended the trial trip of every motor ship of importance.

Involute Internal Gearing.

By H. WALKER, B.Sc.

No. II.*

Internal Gear Design.

The first method of applying the facts stated in the preceding portion of this article is to reduce the pressure angle to zero. It will then be necessary to increase the diameter of the pinion until the full working depth lies above its pitch diameter. The pressure angle being zero, the base diameters and pitch diameters of each gear must coincide, and the pitch point will be the touching point of the two base circles. It follows that the instantaneous centre of curvature of the parts of the profiles at which contact takes place must be the pitch point. Thus the instantaneous curvature of the pinion tooth at any point is the same as that of the wheel tooth at the point at which contact is made, and consequently the closeness of fit between the teeth is a maximum.

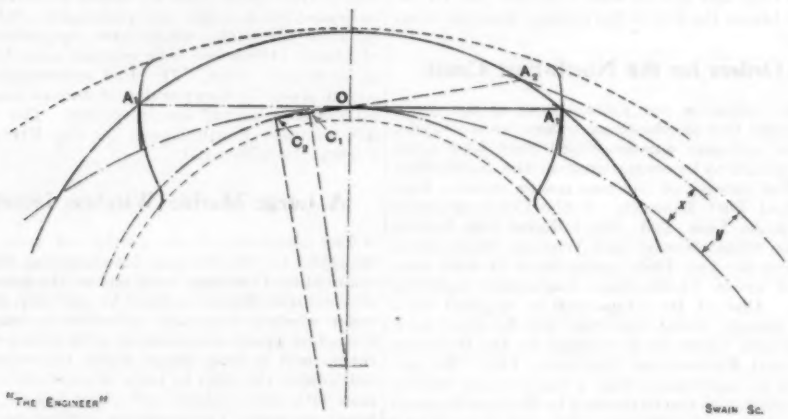

FIG. 12

This type of gear has, however, certain disadvantages, which, it will be shown presently, can be overcome to a certain extent, so that the final gear will represent the best balance of design between the standard and the "zero pressure angle type."

These disadvantages are :—

(1) Minute overlapping of the involutes takes place at points on the profiles below the point at which theoretical contact takes place, owing to the more rapid decrease in curvature of the wheel profile relative to that of the pinion profile.

(2) The contacting portion of the internal tooth profile is small compared with its full working depth. Fig. 12 shows the theoretical length of the contacting portion (x). In actual practice this disadvantage is not very noticeable for gears of moderate ratio, since the profiles envelop each other so closely as to utilise the full working depth of the profile, and it is only with large ratios that the difference is felt.

(3) The velocity of sliding is high at the tip of the pinion tooth compared with that of a standard gear.

(4) Owing to the horizontal disposition of the line of action it is sometimes impossible to insert the pinion into mesh without sliding it in from the end. In Fig. 12 the wheel profiles must be vertical at the points of contact A_1, and from these points downward must tend inwards, thus preventing the pinion from being withdrawn. Except for small ratios, the backlash allowance is usually sufficient to allow the gears to be meshed directly.

(5) The centre distance is variable in one direction only.

Consider the effect of giving a small inclination to the line of action, *i.e.*, changing its inclination from O A_1 to O A_2—Fig. 12.

(1) It can be shown that by this small alteration in pressure angle, overlapping of the involutes is avoided except in the case of the low ratios, which are dealt with separately in the section on trochoidal interference. In the latter case, as explained later, interference is avoided by the use of a higher obliquity than is recommended for average ratios.

(2) The maximum velocity of sliding is reduced from the value O A_1 to O A_2.

(3) The effective profile of the wheel tooth is increased from x to y.

(4) The tooth profiles at the points of contact are no longer vertical, and it will be found that the pinion can be meshed in the usual manner.

(5) The theoretical action of the gears is now the same as that of standard but corrected gears of low pressure angle, and the centre distance can be varied in both directions without affecting the accuracy of action.

Against these advantages must be balanced the fact that the degree of closeness of fit is decreased, since the instantaneous radii of curvature of the profiles at the point of contact are no longer equal; the instantaneous centre of the contacting points has been shifted from O to C_1 for the pinion, and to C_2 for the wheel.

The problem is therefore to find the obliquity of the line of action, which is such that the best results are obtained. The method of keeping the working portion of the pinion all addendum will be adhered to. It is known that this procedure has a good effect on the lubricating action between the profiles, because it avoids the reversal in direction of the sliding action at the pitch line, which is probably a cause of "pitting." Moreover, by this means the so-called "friction of approach" is avoided.

It would be reasonable to base the discussion of a suitable pressure angle on wear, especially since tooth strength is not greatly influenced by a small change in the pressure angle. Fig. 13 shows diagrams of wear made for the three similar sets of gears represented in Fig. 14, having pressure angles of 14 deg., 9 deg. and 5 deg. respectively. A comparison of these diagrams shows that the 14 deg. pinion and wheel are markedly worse at all points than the 9 deg. pinion and wheel. The 5 deg. pinion does not leave much to choose from when compared with the 9 deg. pinion, the average heights of the diagrams being about equal. The wheel diagram of the former is, however, considerably worse than that for the latter—owing to the greater concentration of wear on the wheel profile—and consequently the 9 deg. gears may be taken as giving the best combination. The wearing properties of these gears will be seen to be superior to the wearing properties of the gears, the diagrams of which were given in Fig. 8 *ante*, and which were of the same ratio and tooth depth. Moreover, no account has been taken of the improvement in action caused by transferring the dedendum of the pinion to the addendum.

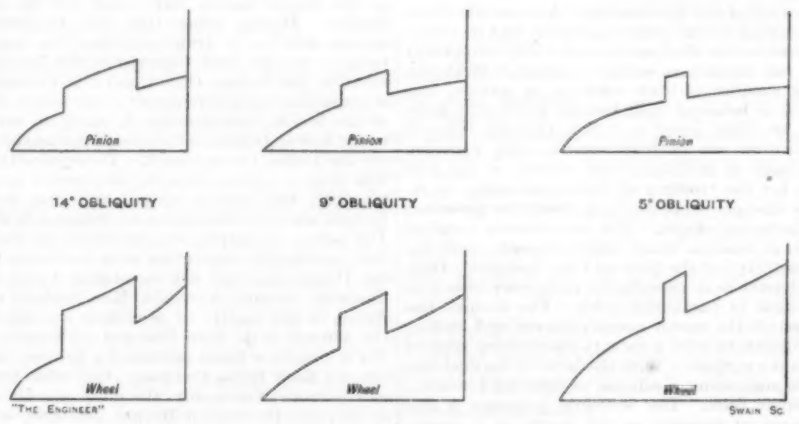

FIG. 13

From a series of diagrams which has been made, it appears that the best obliquity for a given ratio is almost independent of the numbers of teeth, but is found to increase somewhat for an increase in ratio. The following table gives what are probably the best results, but is not altogether infallible, since a decrease of a few degrees may in some cases be sufficient to bring one more tooth into contact, thus considerably decreasing the load per tooth. A final method would be to calculate or set out the line of action from the obliquities given in the table, and to ascertain if a small alteration in pressure angle would be sufficient to bring another tooth into contact, and if such were the case, the lower obliquity should be utilised.

Table of Obliquities.

Ratio.	Obliquity.
2	8 degrees.
3	10 ,,
4	12 ,,
5 and above	15 ,,

For ratios less than 2 to 1, it may be necessary to increase the pressure angle, to the neglect of wear, in order to avoid interference, since below 2 to 1 the numbers of teeth in the pinion and the internal may closely approach each other. This point will be dealt with later in the section on interference.

Tooth Strength.

It would appear at first sight that a pinion with a pressure angle as low as 8 deg. could not be equal in strength to one of 20 deg.; this, however, is not so in the present case owing to the fact that the portion of the involute utilised lies outside the base circle of the gears. Fig. 15 shows various combinations of both types of gears, and it will be apparent that the low-pressure angle types have the stronger tooth forms for both internal and external.

The Question of Interchangeability.

One of the advantages which involute gearing is supposed to possess is that of interchangeability. But to attain interchangeability it is necessary to keep to a fixed standard of pressure angles, tooth depths, &c. Now to attain the best design of tooth form from the point of view of wear and strength, it is necessary to vary these factors for each particular combination, and this variation is, moreover, particularly necessary in the case of internal gears, in which even a 20 deg. stub depth standard is not sufficient to secure the best results in every case. It is necessary, therefore, either to scrap interchangeability, or to continue with the use of badly designed teeth, and it should need no argument to show which of these courses should be taken. The over-rated value of interchangeability itself is very questionable, especially for internal gears, and is probably one of the causes of the present adhesion to time-worn systems of gear design.

Methods of Cutting.

The process of cutting gears designed according to the method outlined above must now be considered.

It will obviously be an advantage if the gears can be cut by means of the same tools as are used for standard gears, external and internal, and it will be shown presently that this result can be achieved by what may be termed a "faking" process, that is, by designing the gears to suit available cutters. The standards of design set out in the previous section will, however, be strictly adhered to.

As pointed out previously, the two methods of cutting internal gear wheels are the gear-shaping process and the formed cutter method. Let us assume in the first case that the gear is too large for the gear-shaper and must be cut by a forming process. Then, since a special tool must be made in any case for cutting the internal wheel, attention can be concentrated on the cutting of the pinion. Fig. 16 shows the pinion which it is desired to cut. Its pitch circle is A B, and its pressure angle is θ. Suppose that a line C D, inclined at a standard pressure angle ψ, say, 14½ deg. or 20 deg., be drawn tangentially to the base circle, and that a circle E F be drawn through D, the intersection point of the centre line and the tangent. Then if we consider E F to be the pitch circle of the pinion, it will have a pressure angle ψ corresponding to this pitch circle. Moreover, the pitch of the teeth as measured on the circle E F will be greater than the pitch on A B in the proportion of $\frac{O D}{O P}$ or $\frac{\cos \theta}{\cos \psi}$.

It will therefore be obvious that a generating cutter of pressure angle ψ and pitch equal to pitch of gear $\times \frac{\cos \theta}{\cos \psi}$ will generate the required involute profile; or, alternatively, a cutter of pitch P and pressure angle ψ will generate a gear of pressure angle θ provided that the pitch of the gear is $\frac{P \cos \psi}{\cos \theta}$. It follows that when designing the gears, the pitch of the gear on which

* No. I. appeared February 5th.

the calculations of centre distance, &c., are based, should be made equal to :—

$$\frac{\text{Pitch of available cutter} \times \text{cosine of cutter pressure angle}}{\text{cosine of pressure angle of gears}}$$

The tooth thickness of the internal wheel on its pitch line must be made conjugate to that of the pinion on its pitch line A B. The pinion thickness may be calculated as follows :—The thickness of the pinion tooth on the line E F—Fig. 16—is equal to that of the cutter on the line G. In the case of the straight sided rack cutter or hob, this thickness may of course be calculated immediately knowing the pressure angle. In the case of the gear-shaper cutter the D C is the line of action, and the pinion is arranged in such a position that the tip of a tooth profile T lies on the line of action produced backwards to A. Actual contact will be taking place somewhere along D C, say, at B. The length of the line A B is obviously equal to the length of the arc F E G measured on the base diameter of the pinion. Now the arc F E G is equal to the width of tooth F E on the base circle plus E G, which is equal to the base pitch of the pinion multiplied by the number of pitches between E and G.

Thus—

$$A\,B = t_p + n\,.\,P_b\,;$$

and in the same way—

$$H\,B = t_w + n\,.\,P_b\,;$$

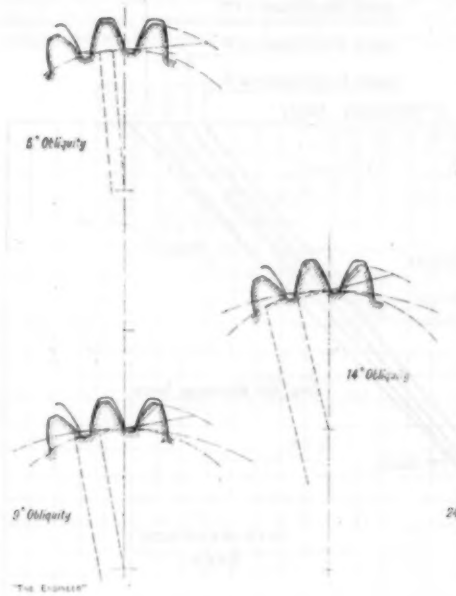

FIG. 14

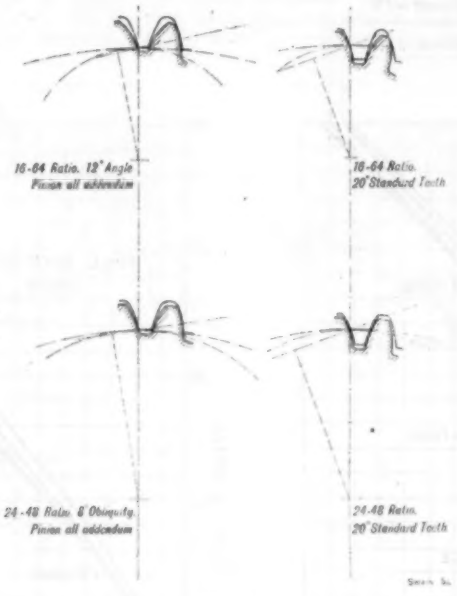

FIG. 15

calculation will be more complicated. Thus in Fig. 17 the thickness C D at radius R_1 is equal to :—

$$A\,B\,\frac{R_1}{R} + 2\,R_1\left\{(\tan\lambda - \lambda) - (\tan\psi - \psi)\right\}$$

in which A B = ½ pitch
R = pitch radius
ψ pressure angle in radians.

and λ is found from the equation $\cos\lambda = \cos\psi\,\frac{R}{R_1}$.

Having thus found the tooth thickness (say, t) of the pinion on the pitch circle E F, the thickness at A B may be found from

$$A\,B = t\,\frac{\cos\psi}{\cos\theta} + 2\,R\,\left\{(\tan\psi - \psi) - (\tan\theta - \theta)\right\}$$

where R is the true pitch radius of the pinion. This value, subtracted from the pitch, gives the circular thickness of the wheel tooth on its pitch circle—or inside diameter. All this procedure would, of course, be simplified if special cutters were made for the gears.

In cases in which the internal wheel is cut by the gear-shaper process the calculations become more complicated, since the tooth thicknesses of both pinion and wheel are fixed by their respective cutters, and, unless special cutters are made, it will usually be necessary to effect some depth correction in order to make the thicknesses conjugate. This correction is found by assuming the pinion to be cut to its correct depth and, as before, finding the necessary width of the internal tooth to gear with the pinion. From this width may be calculated the cutting depth of the internal wheel to give this thickness. The depth thus found will probably differ slightly from the standard depth, and consequently the outside diameter of the pinion must be corrected to a small extent to make its depth coincide with that of the wheel. In many cases, however, the adjustment may be so small as to be neglected, and in most other cases will be small enough merely to alter the running clearance of the gears, provided that the same cutter, or two cutters of the same pitch and pressure angle, are used for the pinion and the wheel.

INTERFERENCE.

A note on trochoidal or internal interference is necessary to make the discussion complete. An example of the type of interference met with in internal gears is shown in Fig. 18. It takes place at the point A, where the tip of the pinion enters the addendum circle of the wheel, the tendency being, as indicated, for the pinion tip to cut away a portion of the tip of the wheel profile. Obviously, the smaller the difference between the numbers of teeth, the greater is the tendency to interference. Other considerations, such as pressure angle, tooth correction, &c., have a vital effect on the presence of interference.

Consider the gear combination shown in Fig. 19, in which t_p and t_w are the widths of the pinion tooth and wheel space on their respective base circles, and P_b is the base pitch, common to each gear. It is obvious that interference cannot take place except beyond the point A, since t_w is always slightly greater than t_p.

Thus, if the intersection of the pinion diameter and the line of action produced backwards lies inside the inside diameter of the internal wheel, interference cannot possibly take place, whereas if it lies inside the working depth of the internal wheel, interference may or may not occur.

The effect of increasing the pressure angle will thus be apparent, since such an increase would bring the point A further away from the "danger zone," and would also increase the difference between t_p and t_w. Stubbing the tooth depth would have the same effect, as also would, in many cases, a long addendum given to the pinion and a short addendum to the wheel; which brings us to the type of gear referred to in a previous section. In that case, the maximum correction has been given to the pinion, but the pressure angle is somewhat low, and consequently for low ratios it may be necessary to increase the pressure angle. The limit to these modifications is reached when the combined effect of high-pressure angle and stubbed depth are such as to make the effective line of action shorter than the base pitch, in which case continuous contact would cease to take place.

A big disadvantage of the standard internal gear lies in interference, and a further disadvantage in the difficulty of estimating whether interference will or will not take place in a given combination. Many conflicting opinions have been expressed on this latter point, and the whole subject is surrounded by a gloom which does not appear to have tempted anyone to probe its depths. A rule often given is that for 14½ deg. gears, the difference in teeth should not be less than 12, whilst for 20 deg. gears of the stub-tooth type, the difference should not be less than 6. The writer knows many cases in which this rule has failed. Moreover, what happens when the teeth are corrected? The usual method is to "cut and try" and leave the result to chance.

In the case of that type of gear in which the pinion tooth is all addendum, however, it is possible to state the exact limits within which interference will take place, these results being obtained by a calculation which is much simpler than that required to do the same thing for a standard gear. Further, the results show that it is possible to use a smaller ratio with this type of gear than with other involute types, unless exceptional methods of design be employed.

The graph given in Fig. 20, the method of obtaining which is explained later, shows the numbers of teeth in the pinion plotted against the minimum number of teeth in a mating gear. The graph is based on a pressure angle of 20 deg., and is applicable for a ten-tooth pinion upwards—below ten teeth the pinion tends to come to a point at the tips. Thus a ten-tooth pinion will gear without interference with a fourteen-tooth—theoretically 13·8 teeth—wheel. For pinions with more than twenty teeth, the difference is fairly constant, and lies between 5 and 6. Thus 6 may safely be taken as the minimum difference.

In order to keep the difference to its minimum, the addendum of the pinion is cut down, so that the line of action is just sufficiently long to allow overlapping of the teeth—the length of the line of action has been cut down to 1¼ times the base pitch. Thus, if the ordinates through the numbers of teeth in the pinion and the internal wheel meet in the area marked "full addendum," the gear may be given a standard working depth (2 ÷ D.P.). If they meet in the area enclosed by the curves, the addendum should be made to correspond to the value given by the nearest (on the small side) of the "working depth coefficient" lines. If the ordinates meet in the "interference area" the combination is, of course, impossible.

A similar chart for 15 deg. pressure angle is plotted in Fig. 21. In this case the difference in the number of teeth in the pinion and wheel is greater than in the previous instance, but it should, of course, be used if possible.

The method of deriving the charts is as follows :—In Fig. 22 are shown the elements of a pair of gears. If interference takes place, it will be at its worst at the point D, where the outside diameter of the pinion meets the internal diameter of the gear. The method is to find the angle D A C through which the pinion must be revolved in order to take it from the position when contact is at the pitch point, as shown, to the position when the pinion tip is at D. From this angle may be found the corresponding angle O B E turned through by the wheel, and the point E will represent the position of the wheel tooth tip when the pinion tooth is at D. If E lies on the lower side of D, interference will not take place, but if it lies above, interference will occur.

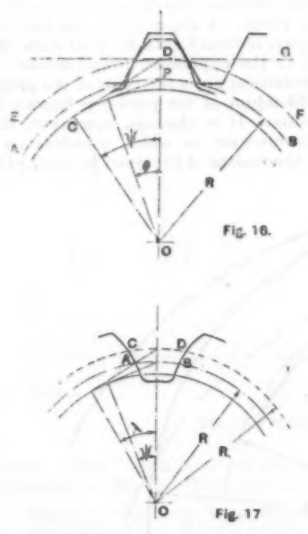

Fig. 16.

Fig. 17

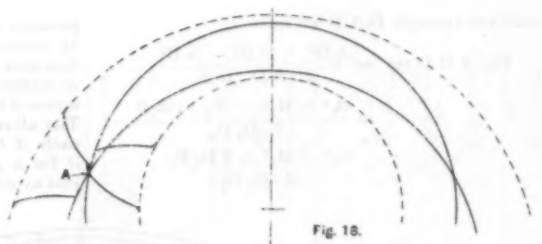

Fig. 18.

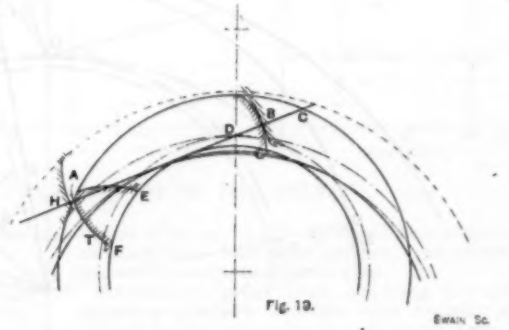

Fig. 19.

"The Engineer" Swain Sc.

The notation used is as follows :—

R_1 = Pitch radius of pinion.
R_2 = Pitch radius of wheel.
O_1 = Outside radius of pinion.
θ = Pressure angle of gears.
θ_1 = Pressure angle of pinion on its outside diameter.

The pressure angle of the pinion on its outside diameter is found from—

$$\text{Cos } \theta_1 = \cos \theta \cdot \frac{R_1}{O_1}$$

Therefore, angle $D A C = \alpha + \beta + (\tan \theta_1 - {}_1\theta) - (\tan \theta - \theta)$, and the corresponding angle turned through by the wheel is—

$$\frac{R_1}{R_2}\left\{\alpha + \beta + (\tan \theta_1 - \theta_1) - (\tan \theta - \theta)\right\}$$

Consequently interference will take place according as β is greater or less than—

$$\frac{R_1}{R_2}\left\{\alpha + \beta + (\tan \theta_1 - \theta_1) - (\tan \theta - \theta)\right\}$$

To find the minimum number of teeth in an internal wheel to gear with a given pinion, the outside diameter of the pinion is calculated such that, for the fixed

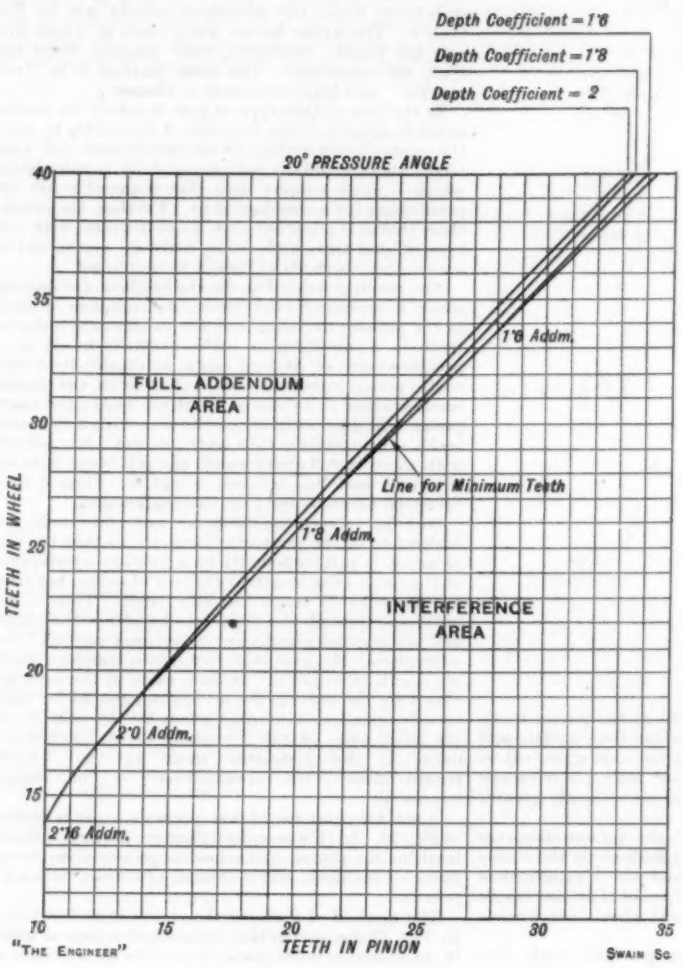

FIG. 20.

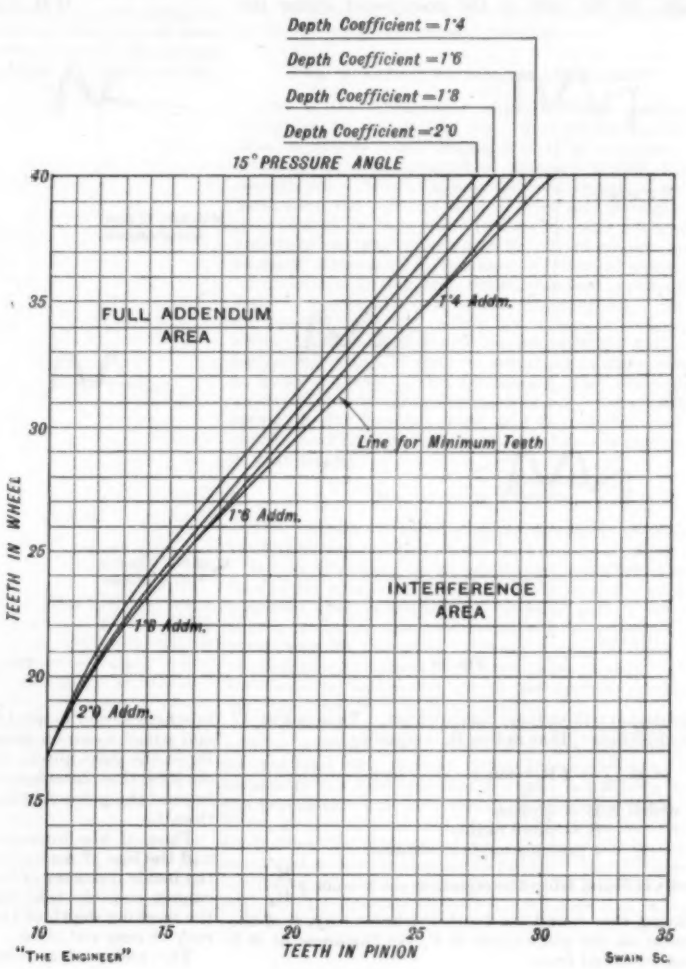

FIG. 21.

From the triangle D A B we have—

$$\text{Cos A D B } (\alpha) = \frac{A D^2 + D B^2 - A B^2}{2 \cdot A D \cdot D B}$$
$$= \frac{O_1^2 + R_2^2 - (R_2 - R_1)^2}{2 \cdot O_1 R_2}$$
$$= \frac{O_1^2 - R_1^2 + 2 R_1 R_2}{2 \cdot O_1 R_2}$$

pressure angle, the effective line of action is equal to 1¼ times the base pitch. A value of R_2, the internal diameter of the gear, is then found by trial such that it makes β equal to the expression found above. A series of such calculations gives the basis of the graph. The allowable addendum of the pinion is known for each of these points. It is obvious, moreover, that if for a given combination in which interference i just avoided, the dimensions of the gears be multiplied

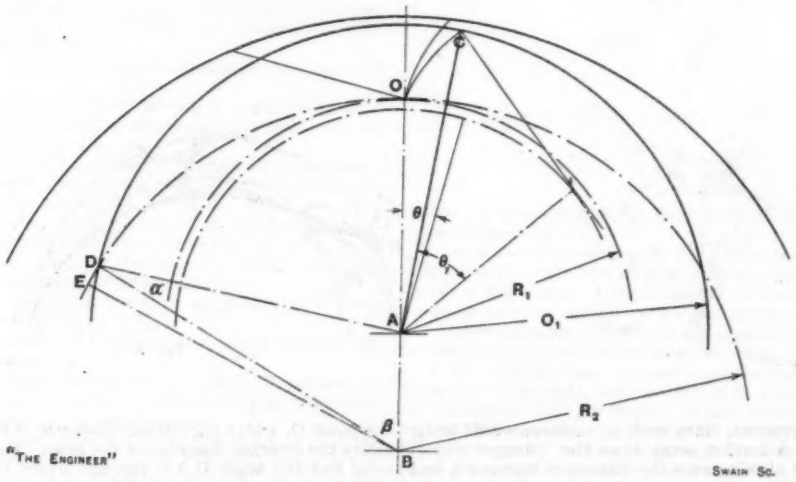

FIG. 22.

Similarly cos D B A (β)—

$$= \frac{(R_2 - R_1)^2 + R_2^2 - O_1^2}{2 R_2 (R_2 - R_1)}$$

from which α and β may be found.

Now angle $D A O = \alpha + \beta$, and angle $O A C = (\tan \theta_1 - \theta_1) - (\tan \theta - \theta)$.

by a known ratio, then if the gears be considered to have the same pitch as before, the working depth coefficient will have been multiplied by the same ratio as the gears. This fact enables the "working depth coefficient" lines to be drawn on the graph. If necessary, a series of lines representing the gear ratio could be added, but the scale adopted for the graph does not permit these lines to be shown clearly, owing to the congestion which would take place near the most used part of the graph.

INTERNATIONAL TESTS OF AERONAUTICAL MODELS.

ACTING on a suggestion made by the Director of Research, the Aeronautical Research Committee decided in March, 1920, to institute comparative model tests in as many as possible of the aerodynamic laboratories of the world. It was thought that such tests, in which the same models would be tested successively by all laboratories, would supply valuable information which had not previously been available. The aim of wind-tunnel experimental work is to obtain reliable estimates of the forces which would be experienced by bodies moving at specified speeds through still air of infinite extent; but in practice it is necessary to hold the model stationary and to generate a flow of air past it. Measurements made in this way are in some degree open to question, in that the forces imposed upon the model may be affected (1) by the limited extent of the air stream in which they are placed, and (2) by the turbulence, which can never be entirely eliminated. The results must, furthermore, depend to some extent upon the methods adopted for connecting the models to the measuring apparatus. Different methods are adopted in different countries, and wind tunnels of varying size and design are employed. There is therefore some uncertainty as to the extent to which a comparison can be made, *e.g.*, between different aerofoils tested in different countries, and this uncertainty, it was thought, would be reduced if comparative figures were available from tests upon the same models.

The tests finally decided upon included the determination of lift, drag and centre of pressure for a standard aerofoil model of R.A.F. 15 section at various angles of incidence. The tests carried out in Great Britain at the National Physical Laboratory and at the Royal Aircraft Establishment are reported in Reports and Memoranda No. 954 of the Aeronautical Research Committee, which has just been published, price 2s. net by H.M. Stationery Office. The report shows the amount of variability that is obtained between the results on the same model tested under a variety of conditions. In general, the agreement between the N.P.L. and the R.A.E. wind tunnels may be considered satisfactory, with the exception of one of the N.P.L. wind tunnels, namely the 7ft. No. 1. The countries participating in the tests are the United States, France, Italy, Holland, Canada and Japan, and will each publish separate reports on the results obtained. Two airship models are also being tested in the different laboratories.

THE new grouping of the German patent classifications will embrace 9739 groups instead of the previous 8000.

Main Line Railway Electrification.

By Sir PHILIP DAWSON, M. Inst. C.E., &c., Consulting Engineer, and
S. PARKER SMITH, D.Sc., M.I.E.E., Professor of Electrical Engineering, Royal Technical College, Glasgow.

No. XI.—U.S.A.: NORTH-WESTERN STATES.*

A.—THE CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY.

1. Reasons for Electrification.

THE electrified portion of the C.M.S.P. Railway constitutes the longest electrified line in the world. The section, when complete, will extend from Harlowton, Montana, to Seattle and Tacoma, Washington, a distance of nearly 1400 kiloms. The distance between Chicago, the eastern terminus, and Seattle, is 3550 kiloms., forming a great transcontinental route. After passing westward from St. Paul, the line traverses the rich plains of Minnesota and Dakota, and ascends into the mountainous districts of Montana, Idaho and Washington, through the Big Belt, Rocky Bitter Root, Saddle and Cascade mountain ranges, and these latter form the natural physical reasons for the electrification.

Owing to the fact that the western section of the railway is a mountain line, it is clear that double-tracking is extremely expensive, and in fact the whole electrified line is single track, except at the stations, where loops, or freight yards, are provided. Limits of haulage by steam locomotives on the long and heavy gradients up to 22 °/₀₀, made electrification essential, apart from the economy in coal thereby obtainable. An important factor in the reduction of coal consumption was the high cost of transport due to the considerable distance from coalfields. Steam haulage over the entire line continued up till the end of 1915.

Train movement is not heavy, there being three transcontinental 600-ton passenger trains per day in each direction, and a fair amount of local traffic, particularly between Cle Elum and the Puget Sound termini at Seattle and Tacoma. Goods trains average four to six per day in each direction, the traffic movement being mainly eastward.

The weather in the district is very rough. The summer is hot and dusty, while the winter is extremely cold—down to about −20 deg. Cent.—and the rainfall is heavy. Steam locomotives occasionally froze up in winter. The great success of the Butte, Anaconda and Pacific Railway—2400 volts direct current—and the rapid development of hydro-electric power in the mountain region, assisted the final decision of the C.M.S.P. Company to electrify its western sections, and it was decided eventually to equip the whole line Harlowton–Tacoma.

2. Choice of System.

The choice of system was influenced, as already mentioned, by the B.A.P. electrification, and further by the fact that hydro-electric power was already developed at 60 periods, three-phase, by the Montana Power Company on a very large scale. The use of three-phase or single-phase equipment would have entailed the use of converter sub-stations to reduce the frequency to 16 or 25 periods. This would have destroyed much of the simplicity of alternating-current working. The voltage first decided upon was 2400, with locomotives identical with those of the Butte-Anaconda line. In the course of contract negotiations, it was pointed out that this voltage was too low for the conditions, and that without the use of regeneration, the main advantages of the electrification would be lost. It was therefore decided to raise the proposed contact line pressure to 3000 volts as a fairly economical and conservative figure not introducing too many uninvestigated problems. Large locomotive units equipped for recuperation were demanded, and the objection raised by the possible effect of such units on the load factor was overcome by the inclusion of a power-indicating and limiting system.

3. Extent of the Present Electrification.

The line electrified is shown in plan in Fig. 1 and in profile in Fig. 2. Harlowton is at the eastern foot of the Rocky Mountains, of which the Big Belt range is a spur. The Harlowton–Avery section—707 kiloms. in length—was opened for electric traction in 1915. In the Big Belt Mountains—see Fig. 2—there is a 80-kilom. stretch of 10°/₀₀ gradient, and between Piedmont and Donald a gradient of 20°/₀₀ over a distance of 34 kiloms. In the Bitter Root Mountains there are 48 kiloms. of 17°/₀₀ gradient. In all, there are thirty-six tunnels between Harlowton and Avery, the St. Paul Pass tunnel in the Bitter Root Mountains being 2·4 kiloms. long.

The western part from Othello to the Puget Sound termini was opened at the end of 1919, adding a length of 339 kiloms. to the electrified zone. This part includes a long 20°/₀₀ gradient in the Saddle Mountains, a 3·7 kilom. tunnel in the Snoqualmie Pass, and a 17·4°/₀₀ gradient in the Cascade Mountains. The "divisions" of the electrified lines are indicated in Fig. 2. They are :—

Harlowton–Deer Lodge, Rocky Mountain divn.	365 km.
Deer Lodge–Avery, Missoula division	342 km.
Avery–Othello, Idaho division	342 km.
Othello–Cle Elum–Tacoma and Renton–Seattle, Coast division	339 km.

The total distance between Harlowton–Tacoma, with the Seattle branch, is 1388 kiloms., and the length of route at present running electrically is 1046 kiloms. The section Avery–Othello—342 kiloms.—will probably be undertaken in the future.

4. General Description.

(*a*) *Contact Line.*—The overhead line for the railway had to be of a heavy section, because of the large demands for current made when a train is hauled up a steep gradient. The contact line voltage being only 3000 volts as opposed to 11,000 or 15,000 volts with single-phase traction made matters still more difficult.

The type of construction employed is shown diagrammatically in Fig. 3. The contact line itself is composed of two wires, side by side, suspended by hangers of a very light construction from a single steel catenary cable. The hangers of one of the contact wires alternate with those of the other, as shown in Fig. 3. This gives a very flexible arrangement, and eliminates "hard spots." To reduce the inertia of the hangers, it was necessary to limit their length, and consequently the span of the supports, which latter is only 46 m. on tangent track with wood poles. This span includes twenty hangers, ten for each contact wire, spaced at 2·3 m.—*i.e.*, 4·6 m. between the two consecutive hangers of one contact wire.

Each contact wire is No. 4/0 gauge (105 mm.²), and is fixed at 7·3 m. above rail level. The poles are of Idaho cedar wood, 12 m. to 14 m. in length, and are placed only at one side of the line on straight sections. On curves a somewhat complex construction, entailing numerous light pull-offs, is employed. There are no devices for regulating the tension of contact wires, nor has experience shown them to be necessary, despite the widely varying temperatures. The variation of sag in the catenary wire is about 20 cm. for − 15 deg. to + 35 deg. Cent. change in temperature.

In tunnels, crossbars of channel section, placed transversely across the track, are hung from the tunnel top by H.T. insulators. These crossbars are spaced 2·75 m. to 4·5 m. apart, and support the catenary wire. Very short hangers, some collapsible, are used to carry the contact wires.

Alternating-current track circuiting is used for signalling purposes, coloured light signals, visible for long distances both by day and night, being used instead of semaphores. As both running rails are used in conjunction with a return feeder for traction current return, the sectionalising of the track circuits is obtained by the use of impedance bonds. The track circuits are about 1650 m. long.

The contact wire supports carry the following circuits :—

1. The contact wires.
2. The catenary cable.
3. The return feeder.
4. The supply feeders, 3000 volts.
5. The signal circuit supply wires.
6. The sub-station control wires. These are used

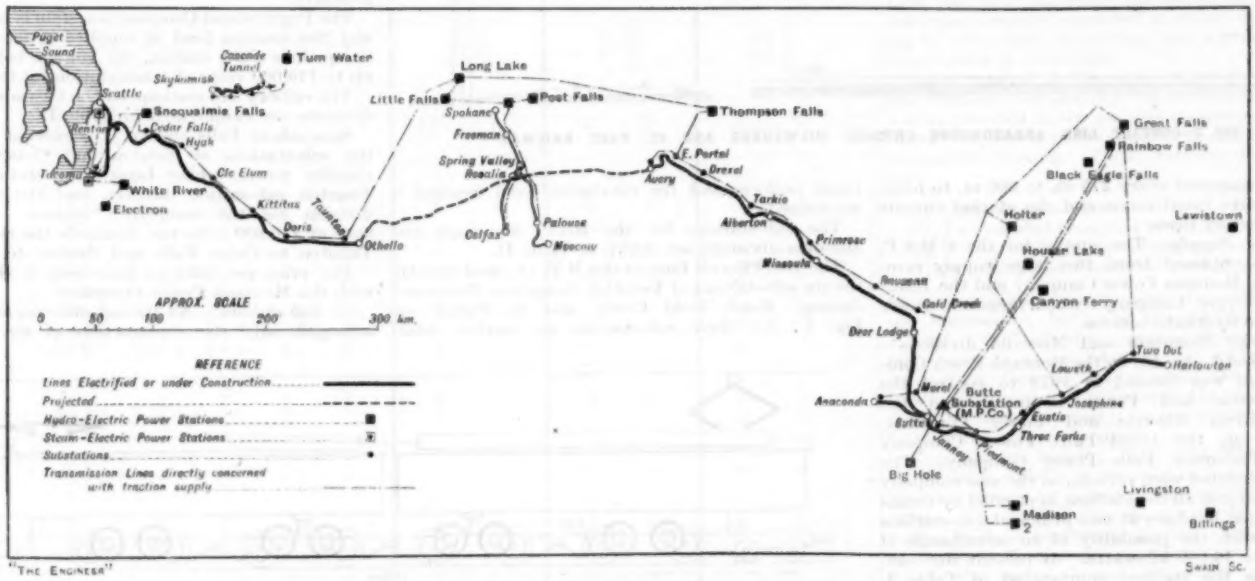

FIG. 1—U.S.A. NORTH-WESTERN STATES ELECTRIFIED RAILWAYS

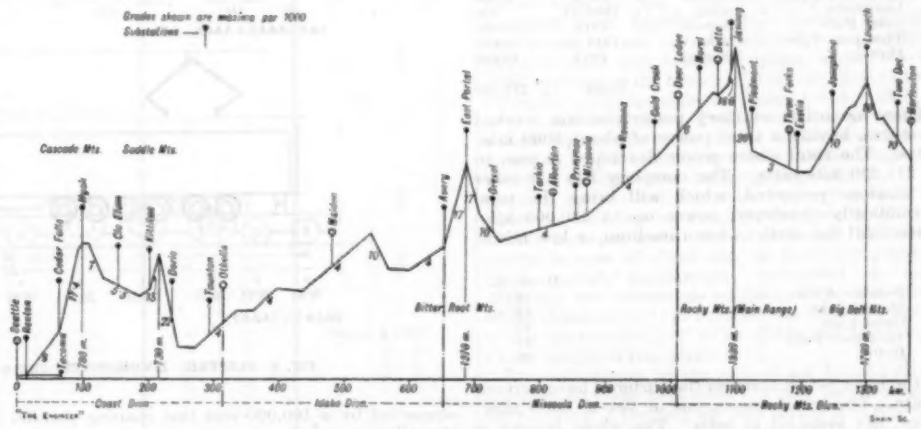

FIG. 2—PROFILE, CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY

* Nos. I., II. and III. (Switzerland) appeared June 6th, 13th and 20th, 1924; Nos. IV. and IVA. (Scandinavia) appeared January 23rd and February 6th, 1925; Nos. V. and VI. (Germany) appeared June 5th and 12th, 1925; Nos. VII. and VIII. (Austria) appeared August 21st and 28th, 1925; and Nos. IX. and X. (France) appeared October 2nd and 23rd, 1925.

for the power limiting and indicating system, and control the sub-station voltage.

The telegraphic communication lines of the C.M.S.P. Railway run parallel to the permanent way, generally about 9 m. from the 3000-volt lines and 18 m. from the 100,000-volt supply lines. The

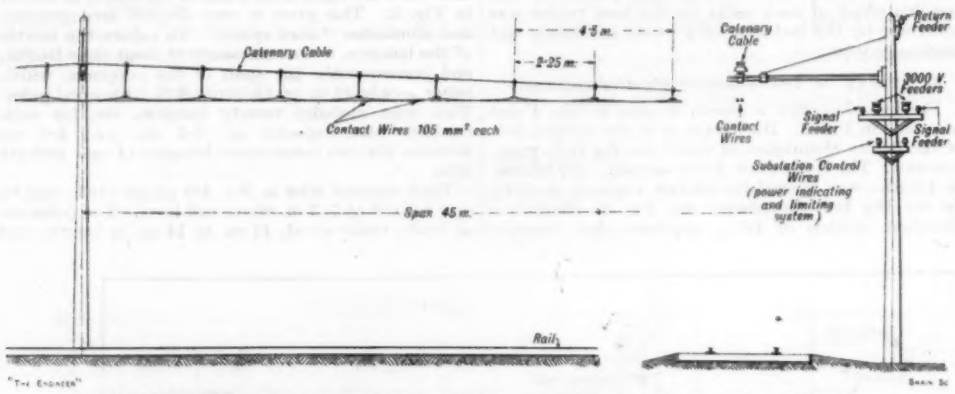

FIG. 3—CONTACT LINE ARRANGEMENT—CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY

lines are transposed every 275 m. to 800 m. to minimise inductive interference, and the station circuits are protected by fuses.

(*b*) *Power Supply.*—The supply for the C.M.S.P. Railway is obtained from two large supply companies—the Montana Power Company and the Intermountain Power Company—which generate power mainly from hydraulic sources.

The Rocky Mountain and Missoula divisions—see Figs. 1 and 2—are fed by the Montana Power Company, which was formed in 1912 to control the Butte Electric and Power Company and the Missouri River Electric and Power Company, and later on the Great Falls Power Company and the Thompson Falls Power Company. The voltages generated were various, so the new company proceeded to join all the stations in parallel by means of low-tension bus-bars at two principal sub-stations at Butte, with the possibility of an interchange of power up to 10,000 kilowatts. At present the company works the stations enumerated in Table I. The actual contracts are with the Great Falls Power Company (for the Rocky Mountain division), the Thompson Falls Power Company (Missoula division), and the Intermountain Power Company (Coast division).

TABLE I.—*Hydro-electric Stations of the Montana Power Company.*

No.	Name of station.	River.	Date.	Capacity. kW.
1	Big Hole	Big Hole	1898	3,000
2	Canyon Ferry	Missouri	1898/1901	7,500
3	Madison 1	Madison	1901/07	2,000
4	Madison 2	Madison	1906	10,000
5	Billings 1	Yellowstone	1907	1,080
6	Livingston	Yellowstone	1906/08	1,500
7	Rainbow Falls	Missouri	1910/16	35,000
8	Houser Lake	Missouri	1911/14	18,000
9	Black Eagle Falls	Missouri	1913	3,000
10	Lewistown	Spring	1906/13	450
11	Great Falls	Missouri	1916	60,000
12	Thompson Falls	Clarks	1916/17	30,000
13	Holter	Missouri	1918	40,000
		Total		211,530

There are other auxiliary power stations, worked by steam, having a total power of about 6000 kilowatts. The total water power developed is seen to be 211,530 kilowatts. The company has a further six stations projected, which will bring the total hydraulically developed power up to 330,000 kilowatts. All the stations have medium or low heads, *e.g.*:—

	Head, m.
Rainbow Falls	34
Houser Lake	19
Great Falls	45
Thompson Falls	15
Holter	30

In the most recent stations the turbines have vertical shafts. The transformers, one or two to each alternator, are installed in cells. The whole lay-out is kept very simple.

The interconnecting lines at high tension (11,000, 50,000, 60,000 and 100,000 volts) total rather more than 3000 kiloms. The unification of such a large system means great economy and continuity of supply.

The power absorbed by the C.M.S.P. Railway only reaches 8 to 12 per cent. of the total power developed, *i.e.*, 14,000 kilowatts, as a mean, on the Harlowton–Avery section. The tariff at which power is supplied to the railway by the M.P. Co. is 0·536 cent per kilowatt-hour at the high-tension feeding points, under guarantee of a minimum monthly average of 60 per cent. of the agreed power, which is 14,000 kilowatts for the Rocky Mountain division and 10,000 kilowatts for the Missoula division. The demand is controlled for each division by means of a "power-limiting and indicating system" so arranged as to indicate and record, at the "train despatcher's" office at Deer Lodge, the total demand being supplied at any instant by the power company to the railway, and to prevent the maximum demand from exceeding the predetermined limiting value. This limiting action is secured by the lowering of the sub-station voltage and therefore of the train speeds. The duty of the train despatcher is to arrange the train movements in such a way that the load is as far as possible made uniform and the maximum fixed demand is not exceeded.

The sub-stations for the Rocky Mountain and Missoula divisions are shown in Table II.

The 100,000-volt lines of the M.P. Co. feed directly the six sub-stations of Two Dot, Josephine, Piedmont, Janney, Morel, Gold Creek, and E. Portal—see Fig. 1. All these sub-stations are further interconnected by a 100,000-volt line running parallel to the railway.

TABLE II.—*Sub-stations on the Rocky Mountain and Missoula Divisions.*

Sub-station.	Distance between sub-stations. km.	No. of motor-gen. groups.	Total power installed. kW.
Two Dot	—	2	4,000
Loweth	55	2	4,000
Josephine	48	2	4,000
Eustis	49	2	4,000
Piedmont	69	3	4,500
Janney	17	3	4,500
Morel	55	2	4,000
Gold Creek	58	2	4,000
Ravenna	52	2	4,000
Primrose	61	2	4,000
Tarkio	60	2	4,000
Drexel	61	2	4,000
East Portal	39	3	6,000
Avery	39	3	4,500
		32 groups	59,500 kW.

A somewhat similar network feeds the Coast division, Othello to Seattle and Tacoma. In this case the energy is supplied by the Intermountain Power Company, comprising the two separate companies, the Washington Power Company and the Puget Sound Traction, Light and Power Company. The hydro-electric central stations of this company are indicated in Table III. The Washington Power

TABLE III.—*Hydro-electric Stations of the Intermountain Power Company (Puget Sound Traction, Light and Power Company and Washington Power Company).*

No.	Name of station.	River.	Capacity. kVA.	Owned by.
1	Long Lake	—	19,500	W.P. Co.
2	Little Falls	—	13,150	W.P. Co.
3	Post Falls	Spokane	2,250	W.P. Co.
4	White River	White	52,000	P.S.T., L. and P. Co.
5	Electron	Puyallup	14,000	P.S.T., L. and P. Co.
6	Snoqualmie Falls	Snoqualmie	18,000	P.S.T., L. and P. Co.
	Total		118,900	

Company's network is fed at 63,000 volts, 60 periods. The railway, however, is supplied at 110,000 volts. Normally the Long Lake station supplies the railway, with Post Falls or Little Falls available in case of necessity.

The Puget Sound Company's system is 55,000 volts, and the traction load is supplied generally by the Snoqualmie Falls station, the voltage being stepped up to 110,000 volts at a sub-station for this purpose.

The railway sub-stations on the Cascade and Coast divisions are enumerated in Table IV.

Snoqualmie Falls station is connected directly to the sub-stations at Renton and Cedar Falls for standby power, whilst Long Lake station supplies Taunton sub-station directly, and the rest of the division *viâ* the company's feeders. Connecting lines at 110,000 volts run alongside the railway from Taunton to Cedar Falls and Renton to Tacoma.

The price per kilowatt-hour here is the same as with the Montana Power Company.

(*c*) *Sub-stations.*—All the sub-stations are similarly arranged, only the construction of the apparatus

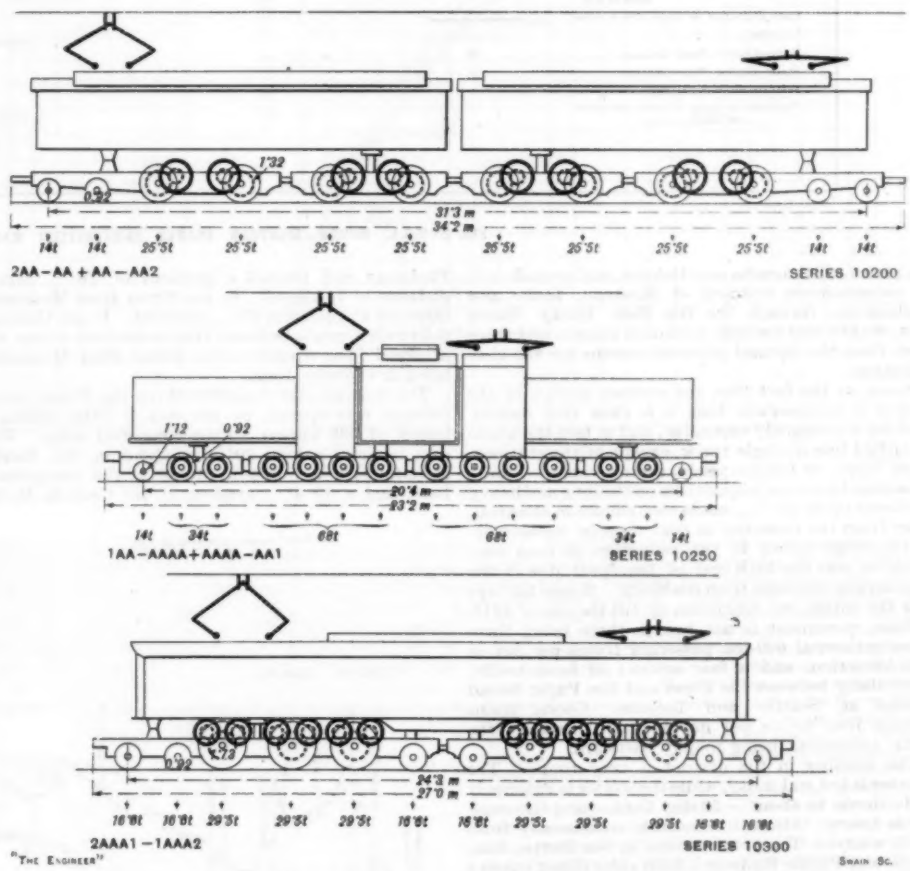

FIG. 4—ELECTRIC LOCOMOTIVES—CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY

differing in some respects. The incoming 100,000-volt lines are taken to high-tension oil switches and then to the transformers which are built for a ratio of 102,000/2300. On the Rocky Mountain and Missoula divisions the connections are delta/delta, while on

TABLE IV.—*Sub-stations on the Coast Division.*

Sub-station.	Distance between sub-stations. km.	No. of motor-gen. groups.	Total installed power. kW.
Taunton	—	2	4,000
Doris	56	2	4,000
Kittitas	37	2	4,000
Cle Elum	51	1	2,000
Hyak	47	2	4,000
Cedar Falls	35	2	4,000
Renton	44	1	2,000
Tacoma	46	2	4,000
		14 groups	28,000

the Coast division the high-tension side is in star and the low-tension in delta. For regulation the high-tension windings, connected in star, have three sets of tappings for 102,000, 97,200 and 94,200 volts. The motor-generator groups are two or three in number, ac-

MAIN LINE ELECTRIFICATION IN THE UNITED STATES

TABLE V.—ELECTRIC LOCOMOTIVES.

Railway.	Series numbers.	No.	Axles. Driv'g.	Axles. Pony.	Axle arrangement.	Weight. Total.	Weight. Adhesive.	Weight. Elect. equip.	Weight. Axle.	Length over knuckles	Wheel base.	Wheel dia. Driv'g.	Wheel dia. Pony.	Motor volt'ge.	No. of motors.	Loco. horse-power (1-hr.).	Tractive effort (1-hr.).	Speed (1-hr.).	Speed (max.).	Weight per horse-power.	Drive.	Gear ratio.	Speed regulation.	Current collectors.	No. of transf'rs.	Cooling of transf'rs.	Braking.
						t.	t.	t.	t.	m.	m.	m.	m.	v.		h.p.	kg.	km./hr.	km./hr.	kg.							
Chicago, Milwaukee and St. Paul Railway	Freight locomotives, 10200–10241	42	8	4	2 AA + AA AA + AA 2	261	204	112	25·5	34·2	31·3	0·92	0·92	1,500	8	3,440	38,000 full field	24·6	56·5	76	Nose-suspension	4·55	Series-parallel and field weakening	Pantographs	0	—	Hand, Air and regenerative
	Passenger locomotives, 10250–10264	5	12	2	1 AA + AAAA + AAAA + AA 1	230	208	106	17	23·2	20·4	1·12	0·92	1,000	12	3,500	21,400 full field	43·6	145	67	Direct gearless	—			0	—	
	Passenger locomotives, 10300–10309	10	6	6	2 AAA 1 + 1 AAA 2	272	172	105	29·5	27·0	24·3	1·73	0·92	750 (1,500)	6 twin	4,680	30,400 full field	38·4	105	38	Geared quill	3·7			0	—	
	Shunting locomotives, 10050–10053	4	4	0	AA + AA	65	65	28	16·2	12·6	9·25	1·02	—	1,500	4	600	9,000	18·5	56·5	98	Nose suspension	3·75	Series parallel		0	—	Hand and air
Butte, Anaconda and Pacific Railway	Freight locomotives, 39–64	26	4	0	AA + AA	72·5	72·5	27	18·1	11·4	7·93	1·17	—	1,200	4	1,280	14,100	24·8	56·5	57	Nose suspension	4·6	Series parallel	Pantographs	0	—	
	Passenger locomotives, 65–68	2	4	0	AA + AA	72·5	72·5	27	18·1	11·4	7·93	1·17	—	1,200	4	1,280	9,300	37·6	80·5	57		3·2			0	—	
Inland Empire Railroad	Freight locomotives —	4	4	0	AA + AA	45	45	22	11·2	7·05	6·43	0·97	—	235	4	540	6,000	24	48	83	Nose suspension	4·9	Transformer tap-pings	Pantographs and trolleys	1	Air	Hand and air
	Freight locomotives —	5	4	0	AA + AA	65	65	31	16·2	11·7	7·27	1·27	—	220	4	700	10,100	19	45	93		4·65			1	Air	
Great Northern Railroad	Freight and pass. locos., 5000–5003	4	4	0	AA + AA	104	104	50	26	16·1	9·74	1·32	—	530	4	1,500	17,200	24·3	48·3	60	Nose suspension	4·26	Voltage control	Wheel trolleys	2	Air	Air
	Freight and passenger locomotives	8	4	4	1 AAAA + AAAA 1	306	236	75	29·6	—	—	1·42	0·92	600	8	2,000	28,100	19·3	40	153		5·03		Pantographs	1	Air	

cording as the sub-station is feeding a steep or a more easily graded track. Each synchronous motor drives two generators connected in series at 1500 volts each. High-speed circuit breakers or "flash suppressors" are supplied to prevent flash-over on short-circuit.

(*d*) *Locomotives.*—Diagrams of the locomotives will be found in Fig. 4, and their main dimensions with other data in Table V. The locomotives Nos. 10,230 to 10,241 (originally 10,100–10,111) are identical with the 10,200–10,229 locomotives. Both are for freight service. Each locomotive consists of two similar units; each unit is carried on two trucks, articulated between themselves by means of Mallet hinges. The leading or trailing trucks have two bogie and two driving axles, while the inner trucks have two driving axles only. The buffer and draw gear is mounted on the end trucks. Drive is separate to each driving axle by a nose-suspended motor, *i.e.*, of the "tram-suspension" type, with gearing on each side. The gear wheels are sprung in order to give elasticity to the drive. The 450 horse-power motors, while insulated to 3000 volts, only work on 1500 volts as a maximum, the two motors of a truck being permanently connected in series. It is interesting to note that the voltage per segment on each commutator is 17·5 volts.

Speed control is by series-parallel connection; field weakening by shunt to the extent of 50 per cent. is also provided in the parallel positions. There are thirty-two notch positions, six of which represent economical running. These economical connections are:—

(1) Eight motors in series.
(3) Two parallel groups of four motors in series.
(5) Four parallel groups of two motors in series.
(2), (4) and (6) as above, with weakened fields.

One pantograph is provided for each unit of the locomotive, but only the leading pantograph is used. The collector pressure against the contact wires is about 14 kilos. In addition to the pantograph there is also a small auxiliary trolley used to restore the air pressure in the reservoirs when the latter are empty and it is consequently impossible to raise the main pantograph.

Regenerative braking both with the motors in series and in parallel is obtained by compounding the traction motors by means of separate exciting generators. The method consists in passing through the motor fields a separately excited current opposite in direction to and greater than that regenerated, which also passes through armatures and fields in series to the line.* The exciters have considerable inertia, both mechanical and magnetic, so that the reduction in field excitation, necessitated by a change in speed, takes place slowly. The motors are therefore subject to surges or hunting which may occasionally result in flash-over. There are thirteen braking notches for use with series or parallel running with and without resistance. Speed can be maintained sensibly uniform.

Other apparatus on the locomotives includes:—A 3000-volt motor driving the compressed air plant; a 3000-volt motor driving the regeneration exciter; a 120-volt control circuit dynamo; and the traction motor ventilating fans.

The gearless passenger locomotives of the 10,250 series, built by the G.E. Company in 1919, are equipped with bipolar traction motors, of which the armatures are mounted directly on the driving axles, without any elastic coupling, whilst the field poles are fixed to the frames. There are twelve driving axles, the wheel arrangement being 1 A A — A A A A + A A A A — A A 1. This gives a large adhesive weight and at the same time a well-articulated construction. The articulation is by Mallet hinges, the two end articulations carrying magnetic flux. The traction motors are naturally of very robust construction, and are insulated for 3000 volts, although the voltage per motor does not exceed 1000 volts, except in case of wheel slip, as there are groups of three motors permanently connected in series. Although the motors are pitched so low (the driving wheel diameter is 1·12 m.), yet the centre of gravity of the locomotives is 1·45 m. above rail level, owing to the height of the cabins.

The pole pieces of the motors are formed of thin laminations; the field coils are very large, owing to the presence of the long air gaps common to this type, to permit the relative displacement of armature and field in the vertical direction. The magnetic flux runs from end to end of each half of the running gear, across each armature, returning through the frames.

Speed control by series parallel arrangements allows of eight economical speeds:—

(1) Twelve motors in series.
(3) Two groups in parallel of six motors in series.
(5) Three groups in parallel of four motors in series.
(7) Four groups in parallel of three motors in series.
(2), (4), (6) and (8) as above, with weakened fields.

In no case does the voltage per motor exceed 1000 volts. There are thirty-nine controller notches.

For regeneration of energy, the twelve motors are divided into two groups of six, of which four regenerate in series, while the two others provide the excitation for the whole group. The two groups recuperate in series below a speed of 35 kiloms. per hour, and in

* See *Journal*, I.E.E.

parallel above it. The range of regenerative braking is from 105 down to 20 kiloms. per hour, or even down to 13 kiloms. per hour for short periods.

Each locomotive is provided with two pantograph collectors, one being a reserve. There is no auxiliary trolley; in case of the air pressure in the reservoirs becoming insufficient when the pantographs are down, a battery of accumulators is employed to drive a small auxiliary air compressor.

The usual additional equipment includes a boiler for train heating.

The locomotives 10,300–10,309 were built by the Westinghouse Company, in conjunction with the Baldwin Locomotive Works. These machines have a single cabin body resting on two "Pacific" type wheel frames, with draw-bar articulation—*i.e.*, a wheel arrangement 2 A A A 1 — 1 A A A 2. The traction motors are arranged in pairs, driving on to a common gear wheel. The latter is supported on a quill, and drives the road wheels by spring connections. The motor pairs are enclosed in a common casing, two or more pairs being connected in series, so that the voltage per armature does not exceed 750 volts. The fields have four main poles and also interpoles.

There are nine economical speeds:—

(1) Twelve motors in series.
(2) Two groups in parallel of six motors in series.
(3) Three groups in parallel of four motors in series.
(4)–(9) Two values of field shunting for each of the above connections.

The locomotive horse-power (one-hour) is 4000. Regeneration is effected as follows:—The traction armatures are connected in series with a stabilising resistance between them and earth, while the field windings in series with an exciter are connected in shunt across this stabilising resistance. The exciter field is fed by an accumulator battery and is adjustable. The exciters are mounted on the rear axle of each frame. The groups of motors can be arranged for regenerative braking in the same way as for driving, *i.e.*, in the series and parallel groups indicated above.

An interesting characteristic of these locomotives is that they are equipped with but one auxiliary 3000-volt motor. All the other auxiliaries are low-voltage machines of normal construction.

The two pantographs are placed directly over the pivots, where the cabin is supported from the frames, in order to keep the pantographs from leaving the contact wires on a curve.

The centre of gravity is about 1·75 m. above the rail level, conforming more to European views in locomotive construction, and giving better running at high speeds.

The G.E. Company has supplied four shunting locomotives, Nos. 10,050–53. These locomotives, of the A A — A A type, are mounted on two bogies, each equipped with two nose-suspended motors, one to each axle. The control is similar to that of the 10,230 series locomotives. Ten series notches are provided and nine for parallel running.

Notes on British Railways by a Continental Engineer.

No. II.*

Permanent Way.

British railways do not employ heavier rails in general, or rails nearly as long as those of the principal railways of the Continent and of the United States, where rails of as much as 40ft. and 60ft., sometimes more, are commonly used. English engineers, having always known how to obviate the defect of joints, have not given so much thought to decreasing the number of rails. In spite of all difficulties, they have succeeded in producing a quality of permanent way which is without equal. Certain points may indeed be open to discussion, but no one can deny that the permanent way in Great Britain is now, and has been for a great many years, absolutely unique, not only on the main express lines, such as those of the East and West Coast routes, where the greatest excellence is maintained, but even on the lateral lines, and are without any defective parts in the whole route. The high quality of the permanent way is due principally to the admirable cleanliness and drainage of the road bed, to the employment of pine sleepers, creosoted, squared and perfectly rectangular, large enough to form an excellent support on the ballast, and close enough together (without being so close as those of the United States of America, where the proximity interferes with the upkeep of the ballast), and to a thick and elastic bed of ballast, to very close inspection of rail joints, and, finally, to the extreme care and conscientiousness which is exercised on the upkeep.

One should note also that if English rails are not as heavy per yard as those of the Continent, the table is about 1 cm. wider, and that gives advantages which it is not possible to discuss here. One may travel from London to Glasgow or from Edinburgh to Plymouth without feeling the shock of a single rail joint. Nowhere else can such a thing be experienced. It is almost impossible to distinguish by the running of a coach the old parts of the road from those that have been recently renewed. The traveller passes from one to the other without the slightest knowledge of the change. The companies never seek to realise an economy at the expense of first-rate quality. That observation is so true that the average British track is often more regular and elastic at the end of several months and years than when it was first laid. The care that is given to inspection and maintenance is seen at once by the complete absence of weeds on the road bed, as well as on the sidings. The removal of weeds is absolutely complete and universal. Hence, English railways have an aspect of cleanness that is rarely equalled elsewhere, at any rate in Europe.

At junctions, at points and crossings, one finds an assemblage of longitudinal and transverse sleepers which form a complete floor and seems to belong to the domain of construction. The bull-headed rail which is used exclusively in England is incontestably the best, when it is strong, well looked after and well maintained, but it will not suffer mediocrity, and ought to be, as in Great Britain, employed with very heavy chairs. The flange rail road can also be made to answer very well when the sleepers are put sufficiently close together, but it can never attain the perfection of a well-maintained chair road. At the same time, one cannot indict the Vignoles rail at a time when it is universally employed throughout the world, with the exception of Great Britain and three French administrations, of which two at least seems disposed to adopt when making renewal. Many engineers who have returned from America have, in discussing American permanent way, fallen into the mistake of attributing the smooth running mainly to its construction, when it is really the result of the employment of three-axle bogies and very heavy cars. In connection with the upkeep of British permanent way, it is to be noticed that the great reduction in train services during certain hours on Sunday offers great facilities for repair and upkeep. The Continent does not enjoy these facilities, for it is mostly on Sundays that the activity of the railways is greatest. Work is carried out very rapidly, owing to the employment of very numerous gangs of workmen, sometimes as many as 100 men being employed on quite a short piece of the road. It should also be remembered that owing to the density of the population and of the traffic, mineral traffic particularly, the receipts per mile are high enough to permit of very heavy upkeep expenses. High quality of permanent way is one of the elements which contributes most to the diminution of the fatigue of a journey, and renders it agreeable and seemingly short. The adoption of bogies, above all with three axles, is the best corrective for mediocre roads. In England the smoothness of the road is felt immediately by that sort of apparent sliding which is characteristic of British trains. It may be experienced elsewhere on new and well-laid roads, but it does not endure through many months of service. The English roads are excellent throughout, but if one should make a choice between them, the London and North-Western, London and North-Eastern, and the Midland might be selected. These roads are unrivalled in the world, and are kept from end to end to the highest standard of uniformity and regularity. The rail beds are kept well drained, the ballast is excellent, the rails are heavy, the joints are level, and never a weed is to be seen on the road.

Owing to the small amount of lateral play that is permitted between the flanges and the rails in England, slicing of the rails at crossings is reduced, with the result that trains pass over them at high speed without sensible shock. If one studies, for example, all the carriages of a British express running at high speed, one cannot help being struck by the smooth motion, by the stability of the vehicles, and by the small relative displacement. Level crossings are almost unknown in England, roads being taken either above or below, as the case may be. The level crossing is now an out-of-date device, and was only adopted to reduce the cost of construction, but has become, in fact, very expensive, when it is guarded, as is invariably the case in France, for example. In the United States level crossings are very numerous in the West, but they are only guarded in the neighbourhood of the great towns, and the Americans themselves are suppressing them little by little. In this case, again, England was the first to lead the way.

It is the practice on English railways to employ the guard rail on many curves, and particularly on those of small radius. This practice is not followed elsewhere, and it certainly assists trains in entering curves.

Whilst recognising these facts, we ought not to overlook the great efforts which have been made by the French railways to re-build their lines after the war, which weighed upon them more heavily than upon those of any other country. We must not forget that many of the northern and eastern lines in France and the Belgian lines, already heavily worn by the density of the German military traffic, were removed and destroyed by the army in retreat, and that other railways of France had to serve during four years under conditions which rendered upkeep extemely difficult. In less than five years, and in spite of difficulties of all kinds, order has been re-established throughout with most praiseworthy energy, and the condition of the lines is now, in many cases, better than it was before the war.

In spite of everything experienced during and after the war, and thanks to their solid construction and to the depth and elasticity of their ballast—of which English engineers more than those of any other nation have always recognised the vital importance—and to the care with which they have been kept up, the permanent ways of the United Kingdom remain, as a whole, unequalled, and certainly the best feature of its railways, and they still lead the way, notwithstanding the improvements which have been made in other countries during the last twenty years or so. As long ago as 1884 the permanent ways of the British lines were almost as good as they are now, especially having regard to the smaller weight of the vehicles.

In connection with chairs, it ought to be noted that the keys are still made of wood, and I have observed that many fall out and that permanent way gangs have frequently to replace or to tighten them up. It is incontestable that the metallic and elastic keys, used uniformly for many years on the French railways which employ chairs, have many advantages. They never fall out, and they tighten themselves automatically. Possibly, British engineers would be well advised to study them.

One cannot help being struck by the confidence which drivers place in the solidity of the road beds. They display an audacity which cannot be tempered by any ancient regulation, and approach at high speed curves of small radius and points, even when they are followed by curves of opposite curvature, or when passenger trains are standing but a few yards from the points. That is done as an every-day practice. These railways are not controlled by formal police rules which date from the early days of their creation. The rule of liberty, when it is accompanied by a strict control placed in the hands of specialists, has borne its proper fruit, and those, of whom there are still some in England, who demand a nationalisation of the railways, exhibit a total ignorance of the question, or seek nothing but political ends.

Interlocking and Signalling.

Interlocking and the block system, either absolute or permissive, originated in England, where they were necessary on account of the rapid development of the railways, and of the density of traffic which existed even before 1870. British signalling to-day, even on third-class lines, is as complete, as clear and as simple as possible, and presents no complication. Interlocking and the distant command of points are due to Messrs. Saxby and Farmer, who have done much to extend their use on the Continent. Since its introduction the system has been the object of many improvements in many countries, and notably in the United States of America, which have been adopted amongst the rest by British railway companies; but in no other place was it adopted so soon or so widely extended as on the railways of England and Scotland. It is in this general use of the system that the main difference consists. Only on the great railways, the great termini of Western Europe, the great provincial stations, is there nothing to desire in this respect; but in England the signal cabins are the same throughout. There is thus a luxury of signalling which few countries can offer. As a consequence, the coefficient of operation is high, but so also are the receipts. In any case, this system, so finely co-ordinated, is worthy of admiration, and is without comparison. Nowhere are the members of station staffs charged with the duties of signalling. There are, throughout, signal-boxes and special signalmen who occupy their time with that matter alone. Station staffs have nothing to do with it. Such a system is obviously costly, but perfectly efficacious.

Other countries have perhaps shown more ingenuity in details, and more of the spirit of research, be it in the mode of transmission of signals, in the application of the automatic block, or the repetition of signals in the locomotive cab, but nowhere has the adoption of the block system been pushed to such extremes. It has, moreover, been carried out judiciously, and in such a manner as to interfere as little as possible with traffic, intermediary sections forming a block being isolated by home and starting signals. In connection with the signalling systems of the British railways, it ought to be noticed that in certain cases the lowering of a signal not only indicates that the road is free, but constitutes an order to proceed, without the intervention of anyone other than the signalman, who thus fulfils a duty which on the Continent falls upon the stationmaster or his assistant. This is the rule at junctions in all countries, but alone in England is used on other parts of the railway. In Great Britain the signalling system is so arranged that the roads are normally closed—that is to say, that the signals stand at "danger" and are only lowered to allow trains to pass through a block. On continental lines, with some exceptions, notably that of the P.L.M., the road is normally open and is closed by the raising of the signals to prevent the passage of trains. The closed road is the better of the two, and ensures the watchfulness of the signalman. The signal is only lowered when a train is announced, and a lapse on the part of a signalman ought to have no more serious consequences than the sudden stoppage of a train. The open-road system, on the other hand, permits a certain degree of *laisser-aller*. Furthermore, on the former system, the lower-

* No. I. appeared February 5th.

ing of a semaphore, which is visible from long distances, informs all persons working on the line and in stations, &c., that a train is arriving.

In short, those lines which, at the outset, adopted the system actually as it is operated in England have every reason to congratulate themselves on their perspicacity.

There remains to be considered the signal itself, the plain semaphore arm, the advantages of which are, in my opinion, many, and which has been adopted by Belgium and Italy, and, with certain modifications, by the United States. France has a special and more complex method of signalling which is less easy for those not accustomed to it to read.†

The English system of signalling is extremely simple, notwithstanding the complications of certain bifurcations, which, however, do not reduce its efficacy, but, rather, the contrary. There is only one type of signal —the plain arm which either stops the train or gives a free road. The notched arm, which is, in reality, only a repeater of the stop signal that follows it, is generally fixed on the same post as the plain arm. No distinction is made, I believe, between block signals and those controlling junctions.

The English semaphore only gives two indications, "road clear" when it is lowered to an angle of 45 deg., and "road closed" when it is horizontal. In that there is a distinct advantage as compared with either round or square discs. When the semaphore indicates "road clear" it is not completely effaced so that it cannot be seen at any distance in the daytime, as is the disc—which at night-time shows white lights—and might just as well be absent. The semaphore says distinctly "You can pass"; it makes it perfectly plain that the road is quite clear; it can be picked up a very considerable distance away, and, all the more so, because the posts are not all of the same type, their height and position being chosen so that they may be best seen, care being taken that nothing can come between them and the approaching train. These signal posts, which are often very high, are of stout scantling, and are painted white so that they can be easily seen.

The French lines have thought it necessary in some cases, in order that certain signals may be the more easily read by drivers who are not fully acquainted with the roads, to place them—in stations or in the approaches thereto—actually over the lines which they control, and that often means that, to carry a single disc, a special bracket and a trellis mast has to be provided, which is an expensive arrangement that does not, moreover, ensure visibility at a distance. Great progress was made some time ago in this direction, and nowadays complete bridges, which carry all the signals and ensure that the lamps are readily lit, are employed in the larger stations.

In one direction, however, British signalling arrangements appear to me to be open to criticism. It is that, saving in large stations and at some junctions, the signal posts are always placed at the side of the line, even when there are more than two roads, and that they sometimes carry several arms, corresponding to several lines, or may be to junctions or cross-overs further on. It is therefore necessary that the drivers should know the line very well from end to end. It is certain that the numerous signal bridges which are placed astride the lines in the approaches to the large terminal stations of Paris answer their purpose very well and give clear and unmistakable indications even to drivers having but small acquaintance with the route. This arrangement is found also on the railways of Great Britain, and it has this advantage, that the semaphore arm gives signals that are more easily read in the daytime at a distance.

A great improvement has been realised by the universal use of a green instead of a white light for "road clear" indication. Drivers cannot confuse green lights with the lights of streets or stations. Furthermore, reliance is not placed entirely on reflectors, as on the Continent, but the lanterns are fitted with lenses, which give, instead of a luminous spot, a small coloured disc which cannot be mistaken for any other light.

Then again—to mention another case in which I think English lines are open to criticism—it has always seemed to me that there is something missing in night-time signalling in England. Both the "stop" and "distant" signals, when they are at "danger," only show a *single* red disc. If they are on the same post that does not matter so much, since the driver knows that the "distant" signal is arranged below the other; but when, as sometimes happens, especially on branch lines, the "distant" signal is isolated and stands alone, if the arm be horizontal indicating "caution," only *one* red light is shown just as though it were a "stop" signal. That, it, seems to me, might lead to confusion if the driver were not well acquainted with the road and the positions of all the signals, for he might be mistaken as to his exact position. I would submit that the French method possesses an advantage in this respect, for "stop" signals show *two* red lights side by side, the second being reflected by a mirror, so that only one lamp is required.

One thing which helps considerably to simplify signalling in England is that detonators are not used for stop signals, except those placed by hand in foggy weather—which indicates that great confidence is felt in the look-out for signals kept by drivers. It is certain that detonators, besides being useful when drivers have had their attention taken off the signals by something, or have forgotten to observe them, constitute a material and indisputable evidence against the driver who runs past a signal at danger, but on lines having numerous roads, with the signals arranged as in England, it would be an exceedingly complex and difficult matter to operate them. So matters are allowed to go on in the way they have done since the beginning, and there seems to be no good reasons why the arrangements should be altered under the pretext of making them more complete. At the same time it seems that several English companies think that audible signals would be a useful addition to the present equipment. The trials that have been made of methods for repeating the signals on the locomotive are proof of that. Experiments in the same direction have been carried out more especially in France as an accessory to the Flamant recorders, but they are not, I believe, pursued with much enthusiasm. They seem to add a complication without which we have done very well for many years.

† The semaphore is used on some French lines as a block signal only.

Hydro-Mechanical Transmission Gearing for Motor Ships.

AT the annual meetings of the Schiffbautechnischen Gesellschaft, which were held in Berlin towards the end of November last, several papers dealing with various aspects of marine engineering and shipbuilding practice were read and discussed. Amongst them was one on hydro-mechanical transmission gearing for motor ships, entitled "Recent Progress in the Propulsion of Ships by High Speed Oil Engines in conjunction with Hydro-mechanical Gearing." The author, Dr. G. Bauer, of the Vulcan Werke, Hamburg and Stettin, dealt with the advance made with hydro-mechanical transmission gear since his paper read at last year's meeting. A redort of this first paper, with an illustration of the gear, was given in THE ENGINEER for December 5th, 1924. Apart from the experience which has been gained with the experimental ship Vulcan, which was described in the paper just referred to, results are now available of the working of two large cargo vessels fitted with marine oil engines and hydro-mechanical transmission gear. These two ships are the Duisburg and the Altenfels, which were built for the German-Australian and Kosmos Lines, and the Hansa Line. They are 450ft. and 470ft. ships respectively with deadweight carrying capacities of 9500 and 11,000 tons. The machinery consists of a twin-screw installation of four-cycle high-speed M.A.N. type oil engines, with hydro-mechanical gearing reducing the speed of the engines from 210 to 79 revolutions per minute. The total brake horse-power developed by the machinery is 4100, the ships having a service speed of 12 and 13 knots respectively.

The results obtained have been particularly good, especially as regards facility in manœuvring. With the engines running at full speed ahead, the time taken from the moment of the giving of the order "full speed astern" until the engine had taken the full load rotating in the opposite direction was only 19 sec., and less than this, 14 sec., were required to pass from "full speed astern" to "full speed ahead."

The increased efficiency of the slow-running 75 revolution propeller, together with the 4½ per cent. saving in fuel consumption, made possible by using exhaust waste heat boilers, counterbalanced the loss of 2.5 to 2.8 per cent. in the transmission gearing. In order to ascertain whether these good results obtained with the four-cycle single-acting engine could be repeated with double-acting engines, trials were carried out with single-cylinder experimental engines of the four-cycle double-acting Beardmore-Tosi type and the two-cycle double-acting Vulcan-M.A.N. type. The four-cycle motor was similar in design to two engines which the firm has in hand for the conversion of the turbine-driven vessel Wulsty Castle, which will be fitted with twin-screw three-cylinder engines, designed for a total output of 1700 brake horse-power. Each cylinder is 20½in. in diameter, with a stroke of $24^{7}/_{16}$in., and full power is developed when the engines are running at 245 revolutions per minute, with a propeller speed of 80 revolutions per minute. The fuel consumption of the single cylinder, taking into account the separately driven air compressor, was about 0.418 lb. of oil per brake horse-power hour. For the tests of the two-cycle double-acting type of engine a single-cylinder M.A.N. engine with a bore of $18^{15}/_{16}$in. and a stroke of 21½in. was used. A total power of 440 brake horse-power was developed at a normal running speed of 240 revolutions, and with a fuel consumption of from 0.396 lb. to 0.418 lb. of oil per brake horse-power hour. The scavenging air was supplied by a separate blower, which together with the independent air compressor would, if taken into account, slightly increase the fuel consumption figures above given. Looking at the results obtained, there would seem to be no doubt as to suitability of the high-speed double-acting motor for ship propulsion. In the vessel Duisburg it would be possible by using double-acting two-cycle engines to reduce the length of the engine-room by nearly 11ft. 6in., whilst the machinery weight would be less by 220 tons than the weight required with single-acting motors. Quite naturally, this saving both in space and weight tends to increase with the adoption of higher engine speeds. Thus, in an installation comprising twin-screw Maybach motors, with hydro-mechanical transmission gearing, which was designed for a total output of 250 brake horse-power, the length of the machinery space was reduced from about 39ft. to 16ft., and the weight from 135 to 40 tons; the larger figures being those for twin-screw triple-expansion steam engines.

The author then referred to the paper read by Sir John Biles at the Spring Meeting of the Institution of Naval Architects, on the relative commercial efficiency of internal combustion and steam engines for high-speed vessels, which paper, he remarked, could be taken as a plea in favour of modern steam machinery. The most advantageous installation was, he thought, a combination of the high-pressure reciprocating steam engine with the exhaust turbine. If hydro-mechanical transmission gearing were to be employed, both the prime movers could be combined on a single shaft, in which case the reciprocating engine would furnish 60 to 70 per cent. of the power, and the balance would be delivered by the exhaust turbine. With such an arrangement of machinery the amount of coal used would be about 0·94 lb. per indicated horse-power, or 10 per cent. less than that of the figure obtained with the best type of marine drop valve engine. Plans were shown illustrating an 850 shaft horse-power installation for a 2200-ton ship and a 4100 shaft horse-power installation arranged for a ship of 9500 tons deadweight carrying capacity.

In a large installation of 31,000 shaft horse-power suitable for a liner, with a steam pressure of 325 lb. and 350 deg. Cent. superheat, steam being raised in oil-fired water-tube boilers, the estimated oil consumption would be about 0·68 lb. per indicated horse-power hour. If, as in the proposed Denny-Parsons turbine steamer, a boiler pressure of 550 lb. per square inch be used along with 375 deg. Cent. superheat, then the consumption of oil fuel would probably be reduced to 0·65 lb. per indicated horse-power hour. If it were shown to be possible to construct the high-pressure part of the turbine so that a high efficiency was given, then a complete turbo-installation could be employed, with a hydro-mechanical coupling interposed between the high and low-pressure parts of the turbine. Such an arrangement would increase manœuvring facilities and give other advantages. It might also be possible to dispense with the astern turbine, which is always a cause of continuous loss.

Dr. Bauer also showed plans for a machinery installation in which a high-pressure reciprocating steam engine, a low-pressure turbine and a marine oil engine were all combined, along with hydro-mechanical transmission gearing, on a single shaft. The advantages claimed for such a grouping included flexibility and the capacity to use cheap fuel, either coal or oil. It could usefully be applied in the case of ships which are required to run at reduced speeds over long periods, visiting harbours in which cheap coal and again cheap oil fuel might be obtained and which require to sail at short notice without losing time for raising steam, while, finally, by forcing the steam plant, large outputs could be obtained when occasion desired.

If the steam plant proved to be so economical and could be combined with simplicity in construction along with reduced weight, so that an oil consumption of 0.68 lb. per shaft horse-power could be obtained, then, in view of the lower price for boiler oil, the steam engine would prove more economical than would the oil motor. The actual economy of steam plant with coal or oil-fired boilers or with oil engines could, according to present prices for coal, boiler oil and Diesel oil, only be determined if the ports at which a ship would bunker were known. Reviewing the progress made with hydro-mechanical transmission gearing, the author stated that in addition to two small vessels, eight ships with an aggregate of 60,000 tons and with machinery totalling some 21,500 brake horse-power are to be fitted with hydro-mechanical gearing, with an average speed reduction ratio of 3 : 1 between the engine and propeller.

The discussion was opened by Ministerialrat Laudahn, who agreed with Dr. Bauer as to the wide future of the high-speed oil engine. It was particularly necessary, however, he said, that the engine should be well constructed.

Director Goos referred to the difficulty experienced in cooling the pistons of these high-speed engines. He found himself at one with the author, however, in regarding the steam turbine installation as the most economical arrangement for large passenger liners. It was for that reason that the Hamburg-American Line had decided to fit steam turbines to the new Atlantic liner Hamburg.

Oberingenieur Müller reported on the satisfactory running experience gained with the direct-geared motor liners Monte Sàrmiento and Monte Olivia, built by Blohm and Voss for the Hamburg-South American Line. The high-speed marine oil engines, which were arranged in two pairs, each pair being coupled by gearing to the twin-screw propeller shafts, had worked most satisfactorily, with a very low fuel oil consumption, and the owners had full confidence in this system of drive.

Director Hartmann shared the view of the author that much was to be expected from the new developments in steam propelling machinery.

Professor Föttinger referred to details of construction connected with the design of the hydraulic part of the hydro-mechanical coupling.

In replying to the discussion, Dr. Bauer said that no criticism had been brought against the high-speed oil engine, which had already been used with conspicuous success in the ships of the Hamburg-South American Line.

The President, Gehermrat Busley, expressed the thanks of the meeting to Dr. Bauer, to whom he presented the Society's Gold Medal.

THE effects of heat upon rocks are important, not only geologically, but also from the point of view of their fire-resisting properties. A valuable investigation which should not, says *Nature*, be overlooked has been carried out by T. Okaya, and the results are published in the *Japanese Journal of Astronomy and Geophysics*, Vol. III., No. 1, 1925. The specfic heats of seventy-one different rocks are given, with a careful petrological description of each of the specimens tested. It is shown that the specific heat depends mainly on the chemical composition, but also in part on the structure. For practically all rocks the value lies between limits of 0·1 and 0·3. Among igneous rocks those rich in soda have higher values than those rich in potash. Sodic andesites, for example, range from 0·24 to 0·28, whereas potassic andesites range from 0·14 to 0·20. Crystalline limestones vary widely, from 0·19 for those poor in calcite to 0·26 and higher in the case of saccharoidal calcite marbles. Results are also recorded for tuffs and granites, and the paper is illustrated by eighteen excellent photo-micrographs.

Linoleum Machinery.

No. IV.*

INLAID LINOLEUM.

THERE are two broadly distinctive processes of manufacturing inlaid linoleum, that is to say, linoleum in which the pattern persists throughout the thickness of the material, and each of these two processes has several minor modifications. The first of these systems is attributable to the late C. F. Leake and is known as the granular, or meal, process, as the linoleum mixture is applied to the backing in that form and is subsequently consolidated. In the second scheme, which was invented by Fred. Walton and is known as the straight line process, the pattern is built up of tesseræ cut from sheets of linoleum, of various colours, which are fixed to the backing and to one another by pressure and heat. The difference in appearance between the two materials is familiar to most householders, the pattern of the granular linoleum having a more or less subdued effect, while in the straight-line stuff the boundaries of the design are sharply defined. It is not our province to discuss the relative merits of the two materials, but rather to describe the processes of their manufacture. Both involve the use of complicated machinery, but it, naturally, works on totally different principles.

Taking first the granular process, which is used in, and was originated at the Staines works, it is obvious that a stock of linoleum mixture in the various colours required must be built up, as it would be prohibitively costly to keep a separate mixing plant running for each of the colours of a pattern. For this reason the mixture, after passing through the final set of mixing rolls, goes through a disintegrator of the cyclone type, that throws it out on to a steel-plated floor in a thin film. The granular material consequently cools down, so that it can be bagged without fear of welding up into a solid mass during storage. The mixture is taken, as it is required by the inlaying machine, and is placed in trays in a refrigerator, so that it is delivered cold and does not tend to clog up into balls.

The machine which performs the inlaying operation is a long horizontal affair, embodying some complicated mechanisms that could not be described in detail within the scope of these articles, while it is doubtful if the proprietors would care for that to be done. It is hoped, however, that the following notes will indicate the general principles involved, but the mechanical processes of producing the required movements must be left to the imagination of the reader.

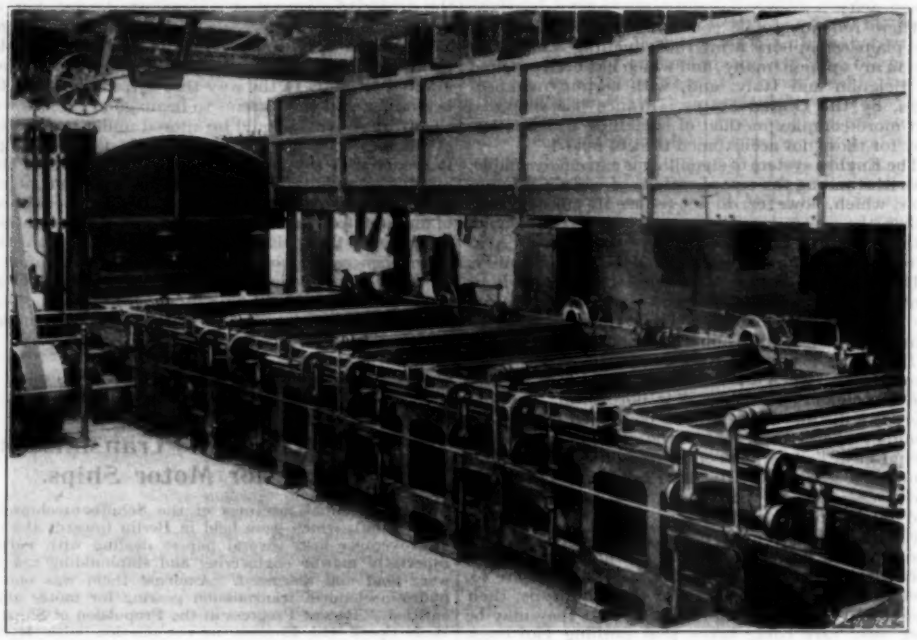

FIG. 26—LINOLEUM INLAYING MACHINE—MELVILLE-BRODIE

It should be emphasised at the outset that all inlaid linoleum patterns, with the exception of those known as "solo" designs, which involve clear-cut curvilinear outlines, are built up of small rectilinear units, either square or hexagonal, much after the same fashion as is a tapestry design. As a consequence the units are made as small as possible, consistently with commercial considerations.

The operation of the inlaying machine may perhaps be best comprehended if the semi-automatic process, which is also carried out at Staines, is first described.

A sheet of thin, tough paper, waxed to prevent the adhesion of the linoleum, is stretched over a table about 2 yards wide by 1 yard long. On the top of this paper there is placed a brass grid which is perforated according to the pattern. The dividing walls of the grid are made as thin as possible and are brought to a knife edge at the bottom where they touch the paper. Over the grid, and in accurate register with it, there is laid a thin zinc stencil, which is pierced to correspond with the grid, but only in the places where a definite colour is required by the design. A small

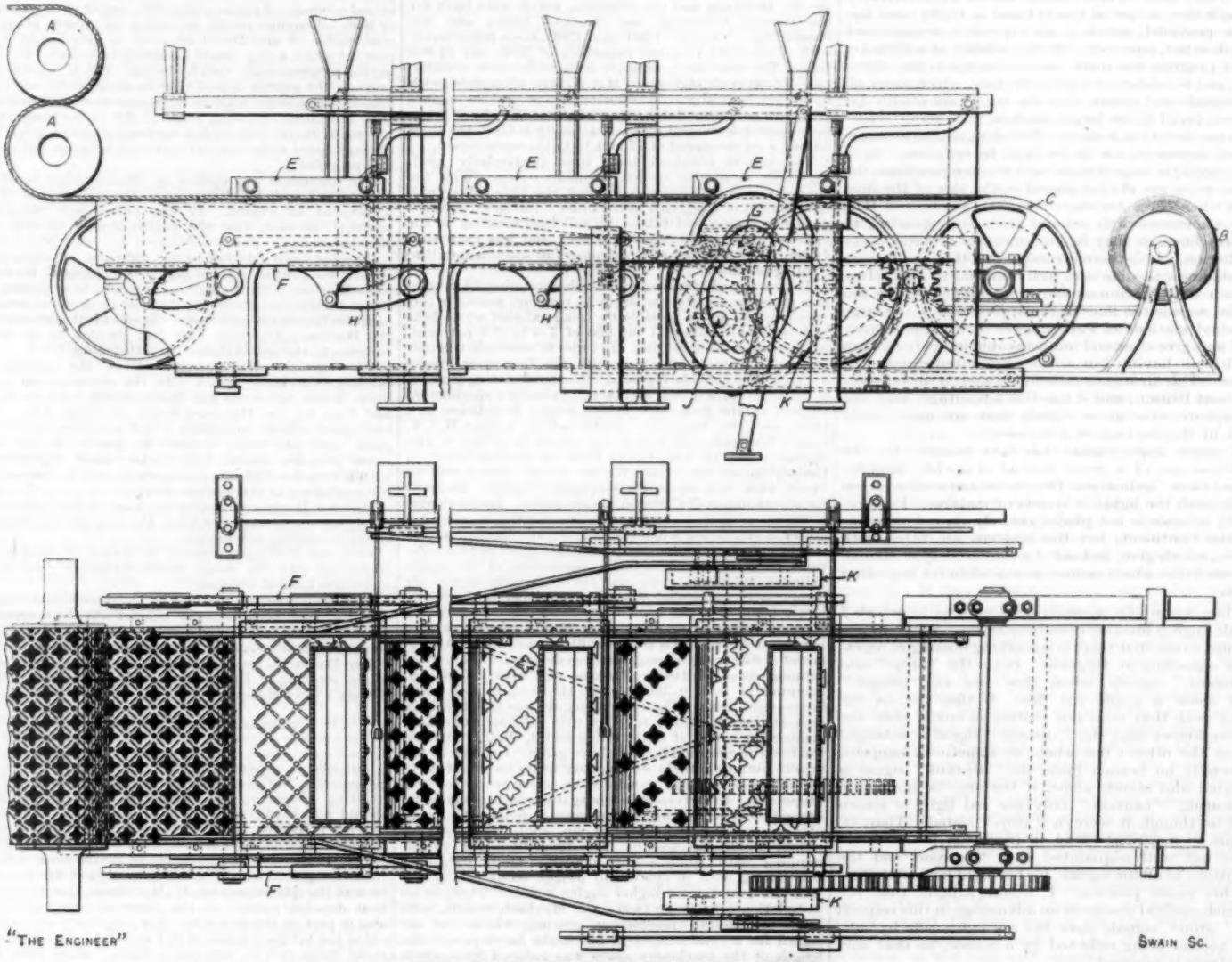

FIG. 25—INLAID LINOLEUM-CARPET-MAKING MACHINE

* No. III. appeared February 5th.

quantity of appropriately coloured linoleum mixture is then thrown on the stencil plate and is brushed about until the openings exposed in the grid below are filled. The stencil is lifted off and another, pierced for a different colour, is put in its place. The process is repeated until the whole of the grid has been filled with mixture and the pattern completely built up. Another plate, furnished with a set of punches which correspond with the openings in the grid, is now brought down and pressure is applied to consolidate the linoleum mixture in the grid. The punches also form a kind of stripping plate to hold the material down on the paper while the grid is lifted off. The taper of the grid walls assists in this operation, while their knife edges ensure the contours of the various colours in the pattern coming into intimate contact at the surface on the paper, which is ultimately the wearing face of the linoleum. When the grid and the punch plate have been raised the strip of linoleum is moved forward to the extent of the width already made, the canvas backing is laid on the top and the combination is passed between the steam-heated platens of a hydraulic press, capable of exerting a pressure of about 1000 tons. This great pressure thoroughly consolidates the linoleum mixture and fixes it firmly on to the canvas backing, while the crevices left between the various units of colour when the grid was raised are filled up by the lateral flow of the material, and the whole mass becomes welded together. The linoleum is rolled up as it is made and the temporary paper backing is stripped off before it is put in the curing stoves.

Besides a number of machines of the type just described, there are at the Staines works several automatic machines in which the stencils are manipulated mechanically; but the most fascinating piece of apparatus is what is known as the "carpet" machine, which works continuously instead of intermittently. The drawing Fig. 25 has been prepared to illustrate the essential features of this machine, but does not actually represent that at the Staines works, as it shows only three colour applying units, whereas the Staines machines have sixteen and eighteen units. This large number of units does not necessarily imply a corresponding number of colours, as one colour is often repeated in several of the units. As a result of the fact that the linoleum is moved through the machine continuously it is possible to use a calender to compress the mixture instead of using a reciprocating press, and the process is naturally expedited thereby, a lineal speed of 6ft. per minute being attained in normal working.

In the drawing Fig. 25 the calender rolls are shown at A A, and from them there is transmitted the drive to the rest of the machine, so that the whole of the movements run in unison. The roll of canvas is indicated at B and the strip, after passing over two guide rollers, goes round a large drum C on to a long flat table. At the opposite end of the table there is another drum, and round it and C there are wrapped two endless steel bands. The bands correspond with the opposite edges of the canvas and are furnished with sharp steel spikes to ensure the even movement of the canvas. One of the drums is geared with the calender rolls and the canvas consequently moves through the machine without any slackness or stretching.

The first operation in coating the canvas with linoleum is to provide it with a thin film of groundwork to prevent the granular material from riddling through its interstices. It then goes on to the actual inlaying process, which is again carried out by stencils, but a grid is not used below the stencil, as it is desired that the outline of the pattern should, in imitation of a woven carpet, not be too clearly defined. Above the table there is a series of shallow trays E E E, the bottoms of which are formed by the stencils. The stencils are pierced appropriately to the colours of the design and sometimes, when one colour predominates over the others to a marked extent, several stencils may be devoted to one colour.

In view of the fact that the canvas is moving continuously through the machine the stencils naturally have to be travelled at a corresponding speed, and for this reason they are provided with pegs, which mesh with holes in the two steel bands running on either side of the table and consequently drag the trays forward. The trays must, of course, be returned to their original positions after they have served their purpose, and the movement is effected in the following manner. On either side of the table there is a board —shown at F F in the drawing—which is reciprocated by a connecting-rod and a crank on the shaft G. The top edges of these boards are provided with notches which engage pegs protruding from the sides of the stencil trays; but the engagement can only take place when the boards are raised to the requisite height. The raising and lowering is effected by a series of bell cranks H H, which carry slipper guides under the lower edges of the boards. These bell cranks are all interconnected and are worked by a cam on the shaft J in such a manner that they lift the boards, engage the notches with the pegs, and consequently lift the stencil trays off the canvas and out of engagement with the pegs on the steel bands, when the stencil has performed its function. The boards are then moved backwards by the crank shaft G to their original positions. The reason for not using the boards for the forward travel of the tray is, of course, the harmonic movement produced by the crank, which would prevent the tray travelling all the time at the same speed as the canvas. It is hardly necessary to point out that the stroke of the tray is half the width of the stencil, as the canvas and the trays move in opposite directions during the return.

The granulated linoleum mixture is supplied to the stencils by a series of overhead hoppers, one for each colour, and is dropped into narrow troughs running across the width of the stencil. These troughs have open bottoms and are weighted to keep them in contact with the stencil. They are travelled across the stencil by the big double-lobed cam K in such a manner that they traverse the surface twice while the stencil tray is moving forward with the canvas, and are returned with the tray during the back stroke. The result of this action is, of course, to wipe the linoleum mixture through the openings of the stencil, and in order to make it as effective as possible, the troughs are given a rapid endways movement as they travel. This movement is provided by a long shaft running along the side of the machine on which there is a number of excentrics. The excentrics are connected with the troughs by rocking levers and connecting links, and the shaft has a long keyway, so that the excentrics can slide with the troughs.

When the whole of the pattern has been built up the linoleum is passed through a vertical calender, with heated rolls, and is compressed into a solid mass. In the process the colours blend together, to some extent, and produce an effect which is an excellent imitation of woven carpet.

The illustration—Fig. 26—is of an inlaying machine by the Melville-Brodie Company, which also works on the stencil principle, but has an intermittent feed and uses a press, instead of calender rolls, to finish the linoleum. It will be noticed that the linoleum mixture is spread over the stencils by troughs which are travelled transversely across the trays by chains, instead of moving longitudinally.

The "straight line" system of making inlaid linoleum is, as has already been mentioned, quite distinct from the granular, or meal, process, and it is carried out to a very large extent at the Staines works.

The broad principle of all straight line processes is to make sheets of linoleum, without a canvas backing, cut them up into tesserae, which will build up into the desired pattern, group them together on a strip of canvas, and affix them thereto by pressure and heat. The difference between the method of working adopted at Staines, and that conceived by Walton, which is employed at one or two linoleum factories, is the substitution at Staines of manual labour for automatic machinery in the grouping of the tesserae to form the pattern. The Walton inlaying machine, described later, is a most complicated and costly plant, which can only justify itself by a long run on any one design; but where girls are employed in building up the pattern it is obvious that making a change in design is a comparatively simple matter. The Staines process also has the advantage, which will be more obvious after the Walton machine has been described, that marbled or grained effects can be introduced into the pattern economically.

The linoleum mixture is prepared at Staines in the normal fashion, and is rolled into sheets a few millimetres thick, in which condition it is quite flexible and fairly soft. For ordinary plain colours the pigment is mixed with the other ingredients, as described in the second of these articles, that is to say, at the start of making the mixture; but when a marbled, or wood grain, effect is desired, a more elaborate process has to be followed. Mixtures of various colours may, for instance, be roughly stirred together and the resultant mass passed through a calender. Then the slipping action of the rolls will elongate the individual particles of different colours and produce them as streaks of colour in the final sheet. A variety of other effects is produced by, for instance, piling together alternate sheets of different colours, pressing them together, slicing the resultant cake and recalendering in several directions to form the finished sheet. Such schemes can, of course, be elaborated considerably, and great ingenuity is exercised by the management in devising economical means of producing novel colour effects in the linoleum sheets.

The sheets of linoleum are taken to a guillotine machine, such as that illustrated by Fig. 27, which is by the Melville-Brodie Company, or to an automatic punching machine, and are cut up into the tesserae for making the pattern. The tesserae are distributed to a large number of tables round each of which there are several girls at work. Over the top of the table there is stretched a band of canvas and the girls, each handling a separate colour, build up the pattern with the tesserae. The material is rolled and is then taken to a calender where it is passed between the

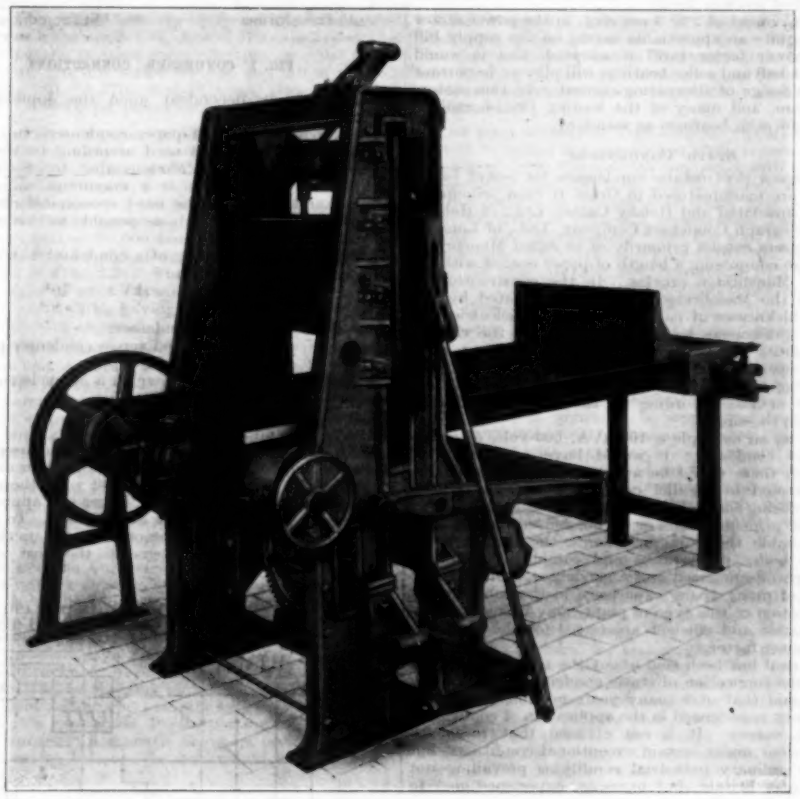

FIG. 27—LINOLEUM; GUILLOTINE—MELVILLE-BRODIE

steam-heated rolls. One or two girls are in attendance on this machine to examine the linoleum as it passes and make good any defects which may have been overlooked previously. The calender compresses the material, and not only firmly affixes it to the canvas, but also welds together the edges of the tesserae. The linoleum is then complete except for the usual processes of curing, &c., common to all grades.

Another interesting process carried out at Staines, but one of which we are not at liberty to give any detailed account, is that employed in making two-colour "tiles" of linoleum. For this purpose linoleum of the two requisite colours is cut up into squares of the size of the tiles and is fed into a press. The press is equipped with a pair of tools shaped to the pattern to be made, and these tools punch out the design from the square of linoleum. The male and the female parts, or what would be, in ordinary press work, the job and the scrap, are automatically transferred to two other press tables. Then a sheet of the other colour for the design is fed between the cutting dies. The resulting two pieces are passed over to the two last out and are squeezed together to make a tile. Expressed in another way:—A white star, for instance, is punched out of a white background and both pieces are moved aside. Then a black star is punched out of a black background. The four pieces are so assembled that there are two tiles, one being a white star on a black ground and the other a black star on a white ground. It is, of course, essential in assembling the two colours, to have the parts in exact

register, as there is no clearance at the joints, and failure to register would result in a very ragged tile. For this reason the machine, which has been made in the Staines Company's own workshops, is unusually substantial, considering the comparatively small force required in cutting the linoleum, and must, of course, be very carefully adjusted.

The Improvement of Power Factor.*

THE first part of this paper summarises the principal types of apparatus employed for the improvement of power factor, and gives a description of the modern static condenser and also of types of power factor rectifying plant that have been developed during the past three years.

The second part outlines various forms of power factor tariff in force in Great Britain, and is divided into two main classes: first, those based on kVA demand, and second, those incorporating a power factor bonus and penalty on the total supply bill.

Systems of metering employed in conjunction with power factor tariffs are briefly dealt with.

BALL AND ROLLER BEARINGS FOR INDUCTION MOTORS.

The adoption of power factor tariffs by supply undertakings has compelled designers to produce an induction motor with a very high inherent power factor, and the introduction by many manufacturers of alternating-current motors fitted with ball and roller bearings has assisted greatly to this end. The smaller the air gap the higher is the power factor, and it is obvious that with ball and roller bearings, where the wear that is attendant upon the use of the journal bearing has not to be contended with, it is possible to use a much smaller air gap, which is a feature of modern design.

An improvement of 2 or 3 per cent. in the power factor represents quite an appreciable saving on the supply bill where a power factor tariff is adopted, and it would appear that ball and roller bearings will play an important part in the design of alternating-current induction motors in the future, and many of the leading British makers to-day adopt such bearings as standard.

STATIC CONDENSERS.

Oil-immersed electrostatic condensers for power factor correction are manufactured in Great Britain principally by British Insulated and Helsby Cables, Ltd., of Helsby, and the Telegraph Condenser Company, Ltd., of London. The condensers consist primarily of so-called Mansbridge plates, these comprising a length of paper coated with tin under the Mansbridge process. In the construction of condensers the Mansbridge plates are separated by the requisite thicknesses of paper used as the dielectric, the number of thicknesses being dependent upon the voltage applied across the terminals of the condenser unit. Generally speaking, each unit of the condenser has a capacity of approximately 1 microfarad, but this may be greater or less according to the special conditions obtaining on the circuit.

To take as an example a 100-kVA, 600-volt, 50-cycle, three-phase condenser; it would have a capacity of 885 μF and there would be approximately 295 separate units connected in parallel on each phase, the phases themselves being connected in delta.

The two principal makers of condensers referred to above assemble the units in frames, the frames being fixed into boiler plate tanks and completely oil-filled. The modern oil-immersed static condenser, which is now the result of many years' experience in the construction and application of this type of plant, may be regarded as a very reliable and efficient apparatus for the improvement of power factor.

A good deal has been said about the risk of resonance owing to the connection of static condensers, but it may be safely said that over many years no difficulty whatever has been experienced in the application of condensers from that cause. It is not claimed that resonance may not occur under certain exceptional conditions, but under the ordinary industrial conditions prevailing not only in Great Britain, but overseas, experience goes to show that it does not.

The static condenser, as built in Great Britain, is essentially a medium-pressure apparatus, the most economical voltage being about 600, but condensers have been, and are, built for direct connection to supplies up to 3300 volts. It should be noted that only in exceptional cases is it cheaper to supply a high-tension condenser, and that the saving is not even then very material, usually not more than 10 to 15 per cent. of the overall cost of the equipment.

Undoubtedly the right place to put the condenser is on the low-tension circuit, as by so doing the improvement will be effected as far out as possible on the distribution network, and it has been found in practice that the call for high-tension is very small compared with that for low-tension condensers.

A case has been reported from overseas of a British-made 100-kVA, 3300-volt outdoor condenser which, for the purpose of test and experience generally, is connected direct across the high-tension overhead transmission line without any protection whatever, and is therefore subject to every kick and surge on the system. Nearly twelve months have now elapsed since the condenser was first connected and it continues to give every satisfaction. This should be sufficient evidence to show that the static condenser does not in reality possess the attributes of frailty so frequently ascribed to it.

A comparatively new development is the low-tension pole type condenser connected direct across pole type step-down transformers, this application being particularly useful in the case of rural distribution. A number of British-made condensers of this type have been working for some considerable time in New Zealand, and it is reported by the engineer of one Power Board that, from the point of view of improved regulation alone, the installation was worth while. In this case, however, the annual saving effected is sufficient to repay about 70 per cent. of the cost of the equipment, and to this has to be added the increase in the useful output of the transformer, as the condenser being connected on the low-tension side of the step-down transformer unloads the transformer of wattless current, and for every 2 kVA of condenser capacity under industrial conditions the load on the transformer will be reduced by approximately 1 kVA.

The efficiency of the static condenser is very high, about 99.7 per cent., so that the losses are almost negligible. A bank of direct-connected condensers having an output of 1000 kVA would have a loss of only 3 kilowatts. Where auto-transformers are used for stepping up the voltage from that of the supply to the most economical voltage for the condenser, the auto-transformer losses have to be added, but the overall losses of large complete equipments for the usual industrial voltages may be taken to be between 1 and 1.5 per cent. of the output in kilovolt-ampères.

It is well known that the output of a condenser is directly proportional to the plate area, and inversely proportional to the thickness of the dielectric, which

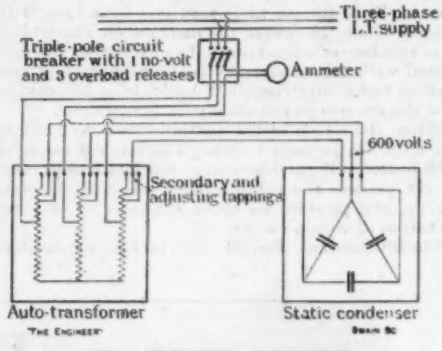

FIG. 1—CONDENSER CONNECTIONS

latter is mainly dependent upon the applied voltage across the plates.

In the construction of paper condensers two or more thicknesses of paper are used according to the voltage applied, and it will be obvious that for each definite number of papers there is a maximum safe working voltage, and to obtain the most economical results it is desirable to work as closely as possible to this maximum safe voltage.

The microfarad capacity of a condenser is worked out from the following formula:—

$$\text{Microfarads} = \frac{(\text{kVA}) \times 10^9}{2\pi f V^2},$$

where kVA = output of condenser.
V = voltage applied across condenser plates.
f = frequency of the supply.

Taking a 100-kVA condenser on a 50-cycle supply, the capacity would be:

At 600 volts, 885 μF,
and at 440 volts, 1650 μF.

With the two principal makes of condenser referred to in the foregoing the type of unit used in either case would be the same, therefore at 440 volts the condenser would require to be 86 per cent. larger and approximately 80 per cent. more costly than at 600 volts. To overcome this it is usual in condenser practice to step up the voltage by means of an auto-transformer to the most economical voltage for the condenser—in the above case, 440 to 600 volts. The auto-transformer is comparatively inexpensive and the overall reduction in price for the complete equipment very considerable.

A high-tension 3000-volt condenser would comprise the requisite number of low-tension condenser units connected in series inside the tank to give the maximum working voltage across each unit. Each unit of the condenser, therefore, would be working at or near its normal designed voltage, and the number of such units would be the same as for a low-tension condenser of the same voltage as that applied across each unit. For example, five units in series each working at 600 volts would give the required result for 3000-volt working; the actual number of 1-μF units used in the condenser would be the same as for 600-volt working, hence the cost would be approximately the same. It is for this reason that a high-tension condenser is usually not less, but more, costly than a low-tension condenser of the same output, and the use of high-tension condensers is not encouraged.

The connections of a standard auto-connected condenser equipment are shown in Fig. 1.

It will be seen that the condenser is connected direct to the auto-transformer, and the windings of the latter therefore provide a path for discharging the condenser on switching out or on failure of supply. If a condenser is connected direct across the supply mains some form of discharge circuit is necessary, and this takes the form either of resistances permanently connected across the condenser terminals inside the tank, or of resistances so arranged inside the circuit breaker as to discharge the condenser on switching out.

Where new step-down transformers are necessary, either as separate units or to bank with existing transformers, and in addition a condenser is required, it is possible to overwind the secondary of the transformer to give the most economical voltage for the condenser. By this means the auto-transformer is avoided and the whole scheme simplified, a considerable monetary saving being effected. The overwinding is a comparatively inexpensive addition to the transformer, and need, of course, be of sufficient copper section to carry only the condenser current.

The transformer provided with an overwinding across which a condenser is connected works in parallel with other transformers, and this will result in the condenser capacity being split up over the whole bank of transformers instead of being confined to the overwound transformer only. This point is important, as should it be necessary to add to, say, two 500-kVA transformers working in parallel in a sub-station a further 500-kVA transformer and, say, a 300-kVA condenser, then the new 500-kVA transformer could be overwound for the condenser, involving no alteration to the existing transformers. Fig. 2 shows the loading and phase angle of the various circuits of an overwound-connected condenser equipment. The load on the primary = 368 kVA (resultant of two secondary loads). External load on secondary at 400-volt tappings = 500 kVA. Internal load on secondary between neutral and 400-volt tappings = 368 kVA (resultant of two secondary loads). Load on 400–600-volt winding = 300 kVA (condenser load).

The majority of supply undertakings in Great Britain, particularly those supplying large industrial areas, have connected to the system during no-load and light-load hours a very large transformer capacity drawing excitation current from the mains. So serious is this in many cases that some supply undertakings, such as the Clyde Valley Electrical Power Company, give in effect a substantial bonus to those consumers who keep static condensers or other power factor rectifiers on the system during no-load hours.

Where a supply undertaking is faced with bad voltage regulation and low power factor, whether or not a power factor tariff is in force, it should be possible to improve matters considerably by connecting direct across the low-tension bus-bars in each sub-station feeding industrial load sufficient condenser capacity to neutralise the magnetisation current of the whole bank. Condensers connected in this way would cut down the losses in transmission and reduce the wattless load on the alternators in the power station, and might in many cases enable one set to be shut down. In addition, an overall general improvement in the power factor of the system would be effected at load times, and a small but additional benefit would be the increased, useful kVA output of the transformers in the sub-station. Such a scheme should not in any way interfere with the improvement of power factor by the individual consumer.

The static condenser is a very flexible apparatus and may be connected to the circuit in any convenient position on the load side of the meters. The condenser may be put across the main switchboard, the sub-distribution board, or the motors themselves, the further out on the load end of the feeder the better, provided the installation is correctly designed.

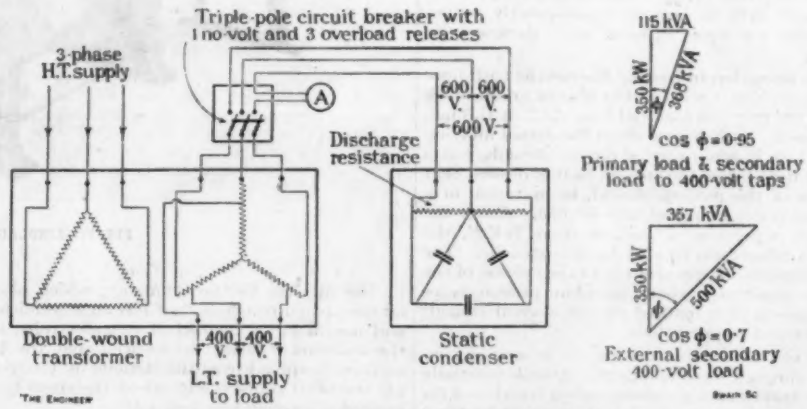

FIG. 2—OVERWOUND-CONNECTED CONDENSER EQUIPMENT

When effecting improvement of a load comprising a number of squirrel-cage or slip-ring induction motors by means of a static condenser, full advantage can be taken of the diversity and the condenser be designed for the average conditions obtaining at the time of maximum load. Such a complete installation has a very high overall efficiency, comparatively low initial outlay, and small upkeep cost.

As to cost, the price per kVA of condenser capacity varies according to voltage, frequency, and climatic conditions, but, taking conditions in the United Kingdom and a three-phase 50-cycle supply at from 400 to 440 volts, the cost of equipments ranging in size from 100 to 300 kVA varies approximately from £3 5s. to £2 9s. per kVA, a good average figure being, say, £3 2s. per kVA.

Taking the average industrial load to be at 70 per cent. power factor, it would be found that, when the power factor is improved to between 90 and 95 per cent., for every 2 kVA of condenser capacity the load is reduced approximately 1 kVA; therefore for every £6 4s. per kVA spent on condensers the demand is reduced 1 kVA. The capital expenditure on supply undertakings varies considerably, and a round figure of £40 to £50 per kVA may be taken. The installation of static condensers should therefore be a very sound and profitable investment for either consumer or supply undertaking.

* Abstract of a paper read by Mr. Edgar Wall Dorey before the Institution of Electrical Engineers on Thursday, February 4th, 1925.

Railway Matters.

THE probability, mentioned in this column on the 5th inst., that the Cannon-street Station of the Southern Railway would have to be closed for some time to allow for track alterations, is now confirmed by the official notice that the use of the station will be withdrawn from 3 p.m. on Saturday, June 5th, until 4 a.m. on Monday, June 28th.

AT the Institution of Railway Signal Engineers on Wednesday last, Mr. Frederick Downes, the telegraph superintendent of the Southern Area of the London and North-Eastern Railway, was elected the president for 1926–27. The annual report showed that 69 new members had been elected during the year, that 3 had died and 14 resigned, and that the total was now 615, of whom 158 are overseas.

THE making of new roads has brought to the railways the carriage of vast quantities of sand, asphalt, road-stone, &c. That fact was used, by a correspondent in the Press last week, as a justification for lowering railway rates. It has, however, since been pointed out that material of the character named is a low-rated traffic, and though its tonnage increased from 5 million tons in 1920 to 12 million tons in 1924, general merchandise fell in the same period from 68½ million tons to 61 million tons.

IN a message to the staff of the London and North-Eastern Railway, Sir Ralph Wedgwood, the chief general manager, said: "Many of us no doubt have heard, and not once or twice only, that on certain sections of the line the public were able to set their clocks in the old days by the running of our trains, but that we have now fallen very far from grace. I am afraid there is more than a grain of truth in the indictment. I am convinced that a combined effort can do very much to remedy our present lapse from grace and to re-establish us on that pinnacle of punctuality which every railwayman desires to occupy."

A TEMPORARY electrical service of trains will be brought into use on the Southern Railway on February 28th between Charing Cross and Cannon-street Stations and Orpington *vid* Chislehurst, Bromley North *vid* Hither Green, and Beckenham Junction, Hayes and Addiscombe *vid* Lewisham and Ladywell. On June 6th it is hoped to open the service between Charing Cross and Dartford over the routes:—(1) *Vid* Greenwich and Woolwich; (2) *vid* Blackheath and Woolwich; (3) *vid* Blackheath and Bexley Heath; and (4) *vid* Hither Green and Sidcup. On July 11th, together with the summer service on the whole of the Southern system, the full electrical services to and from Charing Cross and Cannon-street will be brought into use.

FIVE more contracts for stations on the new Morden tube extension have been placed by the Underground Railway. Messrs. J. Jarvis and Son have been given the contract for the South Wimbledon Station, the Foundation Company, Ltd., that for the Collier's Wood Station. Of the seven stations on the line, six are now in course of erection, and, subject to the present rate of progress being maintained, there is little doubt that the line will be ready for traffic in the summer. Work has also been begun on the stations at Tooting Broadway, Balham, and Trinity-road. The Foundation Company is constructing Tooting Broadway Station, and L. and W. Whitehead, Ltd., are building the Balham and Trinity-road stations. The work is scheduled to be completed in five months.

A COLLISION occurred last October on the Florida East Coast Railway under circumstances which have recently been reported upon by the Bureau of Safety of the Interstate Commerce Commission. A passenger train, drawn by two engines, had done some work at a station where the block system was not in operation. For that reason it was imperative that the flagman should not be called in until the train was quite ready to start. The conductor had the flagman whistled for and the latter rejoined his train, and directly afterwards a goods train came into collision with the standing passenger train. Of the six men with the train the conductor and one of the firemen only knew the road; the two drivers, the head brakeman and the flagman had been in the service of that particular road for only two weeks.

ON page 509 of our issue of May 9th, 1924, we referred to the London and North-Eastern Railway Company having withdrawn its proposals then before Parliament for alterations at Frodingham, in Lincolnshire. That was done because the local authorities made demands which the railway company considered unreasonable. A fresh and modified scheme was passed last session, and is now about to be put in hand. Frodingham is the centre of the ironstone district, and is not only to have a new passenger station with an overbridge instead of a road level crossing, but an enlarged goods and coal yard and new warehouses, and for the mineral traffic a marshalling yard with twenty sorting sidings that will deal with 2000 wagons. A new western curve will give direct access between the North Lindsey Light Railway and the Doncaster direction.

ACCORDING to the Board of Trade returns the value of the railway material exported during the eleven months ended November 30th, 1925, was as follows, the corresponding figures for 1924 and 1923 being added in brackets:—Locomotives, £2,348,430 (£1,729,801, £2,604,111); rails, £1,711,502 (£1,493,066, £2,306,748); carriages, £1,444,433 (£1,080,787, £904,756); wagons, £3,288,487 (£3,074,608, £2,811,218); wheels and axles, £548,249 (£537,630, £893,628); tire sand axles, £413,207 (£566,649, £627,367); chairs and metal sleepers, £942,103 (£1,106,587, £857,770); miscellaneous permanent way material, £1,319,878 (£1,044,974, £1,155,518); total permanent way material, £5,121,178 (£4,959,985, £6,125,124). The weight of the rails exported was 185,219 tons (100,758 tons, 258,105 tons) and of the chairs and metal sleepers, 85,795 tons (88,195 tons, 74,730 tons). During the month of November alone locomotives of the values named were shipped to the following countries:—The Argentine, £25,692; Ceylon, £11,910; South Africa, £9585; India, £6570; South American countries other than the Argentine, £3513. The rails shipped in November included South Africa, £27,578; India, £8583; Straits Settlements, £4117; New Zealand, £2807; British West Africa, £2040.

Notes and Memoranda.

THE wholesale price of cast iron cooking utensils in Nanking, China, is about 1.10 dollar for a vessel 2ft. in diameter and weighing some six catties. This price works out at roughly 4d. per pound.

A TWO-STOREY steel-framed building, measuring 100ft. by 150ft., has been built in Canton, Ohio, without any riveted joints. All the material was put together by electric arc welding, and it is said that a saving in cost of 23 per cent. was effected.

ACCORDING to Mr. C. S. Butts, engineer to the city of St. Louis; the growth of the railways is now resulting in advantage to the rivers. Demands for freight shipment have reached a point beyond the carrying capacity of the roads and movement by water has taken on some measure of revival.

PRIMARY power available in manufacturing industries, mining, agriculture and on the railways of the United States to-day exceeds 150,000,000 horse-power. Of this, nearly one-fifth, or about 33,000,000 horse-power is available in the manufacturing industries, as against 2,346,142 horse-power in 1869.

A NUMBER of measurements were required by the Pueblo, Colorado, Conservancy to determine the depth to bedrock for a long length of sheet piling. Old 75 lb. rails were consequently driven through the overlying soil by a pile driver to a depth ranging up to 38ft., and no effort was made to recover them. The average cost per sounding worked out at 30 dollars.

THE particular physical situation at the Passamaquoddy and Cobscook bays, at the Maine–New Brunswick boundary, is, according to the *Canadian Engineer*, highly favourable to the development of power from the tides. The first-named bay would form the upper pool and the second the lower pool, the respective areas of 100 and of 50 square miles having the relation most effective for tidal power development. In this region the rise and fall of the tide varies from 18ft. to 27ft., and it is said that an average output of 500,000 horse-power could be maintained.

A FREQUENCY changer, which is claimed to be the largest piece of electrical machinery ever designed, is being built by the American Westinghouse Company for the Philadelphia Electric Company. It is to be used for reducing the frequency of the current generated to a value suitable for traction purposes; the motor section of the unit being rated at 60,000 horse-power. When erected, the machine will be 55ft. long, and its height above the foundations will be 22ft. The contract also entails the supply of eight oil circuit breakers, designed for a pressure of 73,000 volts, and having a rupturing capacity of 1,500,000 kilovolt-ampères.

BERYLLIUM, a hard white metal, one-third lighter than aluminium and declared to have remarkable properties, may, says the *Iron and Coal Trades' Review*, find an extensive commercial use as a result of the development of a process for its production at a cost permitting its use as an alloy with aluminium and other light strong alloys. Alloyed with copper, it makes a bronze of extreme hardness and of various brilliant colours. A pound of the metal formerly cost £1000 but now, it is stated, it is being offered at an arbitrary price of £40. However, it is believed that with production facilities on a fair-sized scale, it can be made at £4 per pound.

AN article in the *Engineering News-Record* of January 28th describes the collapse of a 66in. steel pipe made of $^{5}/_{16}$in. plate, through it being subjected to the external atmospheric pressure. The process of reshaping the pipe which was employed is described, but Mr. B. F. Snow, in the article in question, says that results fully as good, if not better, could probably have been obtained at less cost by cutting the line at the end of the collapse, inserting a bulkhead, and raising the pressure to the maximum permitted, in this case about 100 lb. per square inch. Had that been done and pneumatic hammers been used to set up vibrations, he believes the cost would have been less than was the case.

ACCORDING to Professor R. Lessing, the coking industry in this country is burdened with a deadweight of ash, amounting in 1924 to about 1,275,000 tons, and requiring for its accommodation and heating the equivalent of 1200 coke ovens. In the gas industry where coals of rather higher ash percentage are used, a total throughput of mineral matter of about 1,800,000 tons per annum must be assumed. This implies that little less than the equivalent of the carbonising capacity of the Gas Light and Coke Company is constantly employed, and a corresponding amount of retort fuel is wasted, in the useless heating of inert matter, which eventually forms the least desirable constituent of ordinary gas coke.

IN the course of a paper on "The Arc Welding of Seams in Steel Plates," read by Mr. J. T. Carr at a meeting of the Institution of Welding Engineers at Leeds, the author said that because a welder might do a foot of a particular type of welding in five minutes, it did not follow that he could do 12ft. in an hour, and still less that he could keep the same rate up for a whole day. The incidence of nervous tension and fatigue entered into the matter, so that an average welder might be expected to do some 80ft. to 90ft. per day of single run landing-edge welding on ¼-plate, using a 10-gauge electrode. This rate might be increased if all fitting was done for him, and if his electrodes were of a type best suited to the work in hand.

IN Uganda, where the country is generally favourable to road construction, the Director of Public Works estimated the pre-war cost of constructing a road 24ft. wide with a 9in. foundation of laterite and centre width of 10ft. metalled with granite at £200 per mile, and for maintaining it at £30 per mile per annum. On the Gold Coast, the cost of constructing a gravelled road—often impassable in the wet season—16ft. wide, with no heavier traffic than 1-ton lorries with pneumatic tires, is, according to Sir J. E. Eaglesome, estimated at £800 per mile, and maintenance from £80 to £50 per mile per annum. The maintenance of the 1060 miles of road in the West Riding of Yorkshire is estimated to cost this year £951 per mile.

Miscellanea.

THE Corporation of Calcutta is considering a drainage scheme which, it is estimated, will cost Rs. 12,10,500.

IT is proposed to construct an inland dock capable of accommodating vessels of 20ft. draught at Warrnambool, Victoria.

THE Home Office has issued through the Stationery Office, Kingsway, London, W.C. 2, a new List of Authorised Explosives, which supersedes all such lists of an earlier date.

THE actual number of motor cars now in China, according to the latest official figures, is 8508, in addition to which there are also 1130 motor trucks and omnibuses and 1100 motor cycles.

THE output of coal from the mines of Great Britain for the week which ended on January 23rd was 5,405,300 tons, as compared with 5,427,000 tons for the corresponding week of last year.

THE Government of Ontario is this winter trying to keep the main highways of the province clear of snow, and has, for this purpose, acquired equipment costing 100,000 dollars, while 1500 miles of snow fencing will be required.

A SCHEME for the development of hydro-electric power on the Perak River, State of Perak, is being undertaken by Sir W. G. Armstrong, Whitworth and Co. It will provide a supply of power to the tinfields in the Kinta Valley, and will involve an expenditure of £1,250,000.

A DEFINITE plan has been prepared for the establishment of a Research Association for the Paint and Varnish Industries, under the scheme of the Department of Scientific and Industrial Research. The research contemplated at present will cost £5000 a year for the next five years.

THE Worshipful Company of Tin-plate Workers has made arrangements for an official tour in April in the Manchester district and in Monmouthshire to study the wire-working industry. Arrangements have also been made to enable members to inspect the ancient wire works at Tintern.

THE total number of Transatlantic vessels to enter the port of Montreal last season was 1040, representing a net register of 4,744,793 tons, as compared with 988 in 1924, representing 3,597,147 tons. For the previous eight years the figures are as follows:—In 1923, 892, representing 3,221,781 tons; in 1922, 969, representing 3,453,059 tons; in 1921, 807, representing 2,598,494 tons; in 1920, 638, representing 2,020,519 tons; in 1919, 702, representing 2,041,639 tons; in 1918, 644, representing 1,910,621 tons; in 1917, 579, representing 1,984,233 tons; and in 1916, 569, representing 1,965,161 tons.

A JOINT committee of the General Contractors' Association, the Associated Contractors of British Columbia and the Building Trades Council of Vancouver, B.C., recently reached an agreement under which a system of apprenticeship will be established for carpenters. When this scheme is found to be operating successfully the joint committee will endeavour to establish a similar arrangement with regard to bricklayers and masons, and the other crafts represented on the Vancouver Building Trades Council, namely, plumbers, painters, sheet metal workers, structural iron workers, electricians, plasterers and plasterers' labourers, mill and factory workers, and steam and operating engineers.

SOME hundreds of famous British factories will be opened to traders in this country, and from all parts of the world, during the period of the British Industries Fair in Birmingham, February 15th to 26th. There they will see, in the actual making, the goods they will sell in the business year which, for many classes of product, begins with this national trade display. Until manufacturers exhibiting at the Trade Fair in Birmingham originated the idea of showing customers over their works, at the time of placing orders for the year, many retail traders had practically no technical knowledge of the goods they distribute to the public. The advantages of this policy, which is more and more widely adopted at each Fair, are at once apparent. Not only do buyers take a keener interest in the goods they see made, but they are also in a position to render more direct service to their own customers.

THE Ontario Government recently announced that a power development plant would be erected at Alexandria Falls on the Nipigon River for the production of 50,000 horse-power to supplement the 55,000 horse-power already developed in that district. The cost is estimated at 7,000,000 dollars, which will bring the Government's investment on the Thunder Bay power project up to 18,000,000 dollars. The Government has co-ordinated its timber, pulp and power policies for the development of that region, and the project for increasing the output of power follows the sale of important pulp areas, the pulp companies being under contract to take the power they require from the Nipigon hydro-electric system. The 50,000 horse-power now produced is already contracted for. The new plant will be erected about one mile and a half below Cameron Falls, where the present plant is situated, and delivery of power will be begun in 1928.

A SURVEY of the most recent information relating to business tendencies reported to the British Engineers' Association by the manufacturers concerned reveals the interesting fact that contracts are not only being secured in the face of the keenest continental competition, but in certain lines of engineering manufacture the continental home markets are being successfully invaded. Considerable success is, for example, reported to the Association by a firm which has recently obtained large orders for its fuel economiser plants from Holland, France, Italy and Belgium. The firm attributes its success to the policy of sending abroad representatives with a thorough knowledge of economisers, to the production of up-to-date designs, which have enabled the installation of these plants integrally with the boilers, and to the results of research work which it has for some time been carrying out in connection with high-pressure cast iron, and through which they have successfully evolved a plant that will work in conjunction with boiler pressures of over 700 lb. per square inch.

THE BRUGG SUB-STATION OF THE SWISS FEDERAL RAILWAYS

(*For description see page* 188)

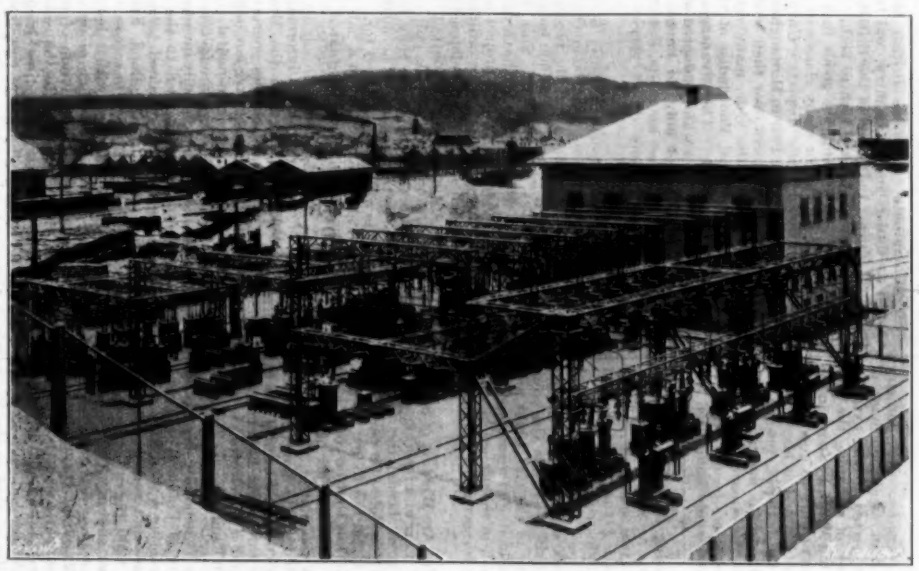

FIG. 1—GENERAL VIEW OF THE STATION

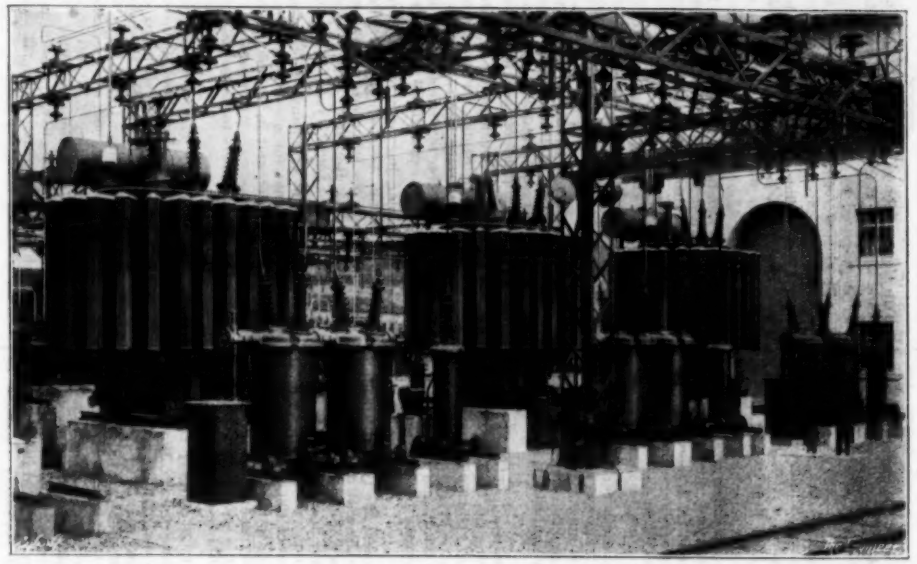

FIG. 2—3000-KILOVOLT-AMPERE TRANSFORMERS

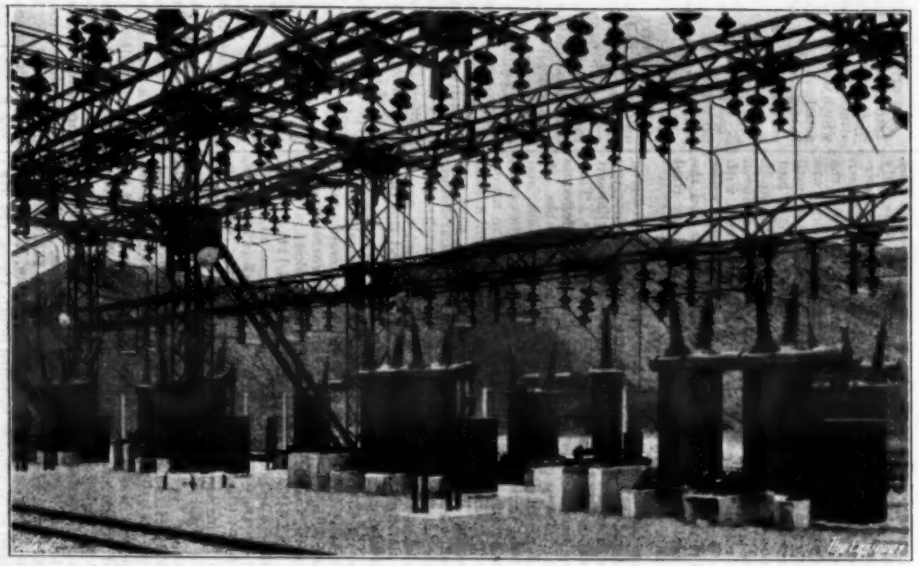

FIG. 3—TWO-POLE 60,000-VOLT SWITCHES

FIG. 4—15,000-VOLT SWITCHGEAR

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THE ENGINEER.

FEBRUARY 12, 1926.

Misunderstandings about Steam.

CONSIDERING that a hundred years have passed since Carnot laid the foundations of thermodynamics and that the steam engine ever since has been the subject of unremitting study, it is curious that strange ideas concerning the behaviour of steam are still occasionally to be found. We do not refer to such matters as super saturation, molecular aggregation, or the *modus operandi* of evaporation and condensation, which as yet are hardly out of the hands of the physicists, but to the everyday action of steam as used in an engine. Were the subject less important, the fallacies might be passed over without comment, but steam power being the basis of modern industry, its principles cannot be too widely understood. At the present moment great interest is being taken in the use of steam at very high pressures. It seems to be taken for granted that a greater proportion of the heat in the fuel can be turned into work, if higher pressures are used, but in spite of all the thermodynamic teaching of the schools, there are still people about who do not seem to understand why this should be so. One of the naïvest explanations was that given before a certain technical institution not so very long ago by an advocate of high-pressure steam. He pointed out that the sensible heat in steam increased, and the latent heat diminished, as the pressure was increased, and then, on the grounds that as it was only the sensible part of the total heat which was any good—or words to that effect—he drew the conclusion that a thermodynamic gain resulted from the use of higher pressures. The major premise of his syllogism was, of course, correct, and so, only by chance, was his conclusion, for the reasoning was vitiated by a blunder in the minor premise. Latent heat, indeed, seems to be the bugbear of many people who ought to know better. They grudge having to put it into the water into the boiler, and hate to see it carried away by the circulating water. They seem to think that some sort of loss is going on which could be much lessened if only water did not require so much heat to convert it into steam. As a matter of fact, it is, of course, its high latent heat which makes water such an admirable working fluid for a heat engine. Without that characteristic the average temperature at which heat could be given to the working fluid would be much lower, so that the condition which Carnot pointed out as necessary for the highest efficiency could not be so nearly approached. If any one doubts the truth of this reasoning, he can soon convince himself by a little arithmetic. It can be easily shown, for instance, that a perfect engine working on the Rankine cycle, with steam at 200 lb. pressure and exhausting into a 28in. vacuum, would have a thermodynamic efficiency of practically 28 per cent. Suppose now that a new sort of water were to be discovered, with all the properties of ordinary water, except that its latent heat was only one-tenth as great. If this water were substituted for the other, the efficiency of the engine would at once fall to about 18.7 per cent., not to mention certain serious practical disadvantages which would also be involved. With a perfect engine working on the Carnot cycle the efficiency would, of course, be the same whatever the latent heat. With the ordinary Rankine cycle of operations, it is interesting to note that the greater the latent heat of the working fluid the more nearly is the efficiency of the Carnot cycle approached, and no heat engine can have an efficiency greater than that.

There is another extraordinary persistent delusion in many minds, namely, that somehow or other it is the total heat in a pound of steam which determines its thermodynamic value. According to this idea, the highest efficiency would be obtained by using steam with the maximum heat contents per pound. This opinion was expressed by one of the speakers in a discussion on "High-pressure Steam Generation" in London last winter, and he apparently echoed the belief of others present. He said: "I take it . . . that the point at which the latent heat is falling off more rapidly than the sensible heat is rising, is the point of maximum pressure for the best efficiency. If the pressure be increased still further the resultant vapour will contain less heat units than steam at a lower pressure, and will therefore be capable of less work." Now, taking steam superheated to a constant temperature, the total heat per pound falls continuously as the pressure is increased, yet the available heat, and therefore the efficiency of the cycle, continuously increases. With saturated steam, according to Callendar, the total heat rises to a maximum of 1232.8 B.Th.U. per pound at about 1500 lb. pressure, and drops to 1232.3 B.Th.U. at 2000 lb., which is as far as his tables go. The difference is, of course, practically insignificant, but there does exist a falling off, and so, according to the theory just referred to, there should be a falling off in efficiency. A perfect engine working on the Rankine cycle would, however, require only 7.24 lb. of steam per kilowatt-hour, with the 2000 lb. steam, as against 7.46 lb. with the 1500 lb. steam, a vacuum of 28in. being assumed in both cases. There is nothing like a little arithmetic to run these fallacies to earth. To take a more striking example of a lower efficiency being associated with a higher total heat, we will consider two perfect engines, one using steam at 100 lb. pressure and a temperature of 560 deg. Fah., while the other uses steam at 300 lb. pressure and 418 deg. Fah. Both work on the Rankine cycle and exhaust at a 28in. vacuum. The steam in the first case contains 1313 B.Th.U. per pound, or 100 B.Th.U. more than the other, and the temperature is also 142 deg. Fah. higher. The first engine, nevertheless, will only have an efficiency of 25.7 per cent., and will require just over 10 lb. of steam per kilowatt-hour, while the second will only consume 9.4 lb., its efficiency being 29.9 per cent. Thus, in spite of using steam at a higher temperature and containing more heat units per pound, the first engine will show a much inferior performance to the second. There is no mystery about this. The heat to make the 300 lb. steam has to be put into the water at a higher average temperature, because the boiler pressure is higher, and so has a greater thermodynamic fall to the condenser temperature.

In his interesting paper on "The Development of Increased Efficiency in Steam Application for Marine Purposes," read on February 9th before the Institution of Engineers and Shipbuilders in Scotland, Sir James Kemnal touched on the increase of efficiency with high-pressure steam, but unfortunately his remarks on this subject are so condensed that they might be misunderstood by unwary students of his paper. He states that "the gain due to higher steam pressures arises partly from the fact that the heat content per pound of steam, whilst it increases slightly up to 350 lb. per square inch, commences then to diminish slowly, and therefore as the pressure is increased above 350 lb. no more heat, but theoretically slightly less has to be transferred from the fuel to the water at the increased pressure. Consequently, with suitable arrangements of the turbine, greater

utilisation of the fuel can be obtained from the steam at the higher pressures." Callendar's tables, which are now generally accepted as the most correct, show that the heat content of saturated steam continually rises with the pressure up to about 1500 lb.—as we have already mentioned—and then falls extremely slowly. Sir James bases his argument on Stodola's determinations, which are shown graphically in the paper. If these are taken as correct, and if the heat content of steam is greatest at 350 lb., this would be the best pressure to work at, according to the view we have combatted above. Sir James' remarks, however, might be taken to mean that 350 lb. is just the pressure to be avoided if efficiency is sought. The fact, if it be a fact, that less heat is put into a pound of steam at the higher pressures has no significance unless the temperature is also taken into account. The curve he gives shows the total heat rising from about 1199 B.Th.U. per pound at 200 lb. pressure to nearly 1203 B.Th.U. at 350 lb., and then falling back to 1199 B.Th.U. at about 620 lb. pressure. Hence, if total heat were the main criterion of efficiency, steam at 200 lb. should be as advantageous as steam at 620 lb., and better than at any pressure between these values. We do not, of course, associate Sir James for a moment with any such a conclusion. His enterprise in producing commercial boilers steaming at 800 lb. per square inch, with a steam temperature of 824 deg. Fah., now in use on the Continent, is sufficient evidence that he, at least, has no doubt as to the direction in which thermodynamic efficiency is to be sought, and we should not have selected a casual remark in his paper for comment had it not been liable to misconstruction by those not so conversant with the subject as he is. The question of what is the best pressure and temperature of steam is almost entirely a practical one. All that theory can do is to point out that the best thermodynamic efficiency is possible when the heat is put into the steam at the highest average temperature, and Carnot did that a hundred years ago.

Power Factor.

WHILE few electrical matters have claimed more attention than power factor and its correction, additions to the extensive store of literature on this subject continue to be made. Two new papers, one on "The Improvement of Power Factor," by Mr. Edgar Wall Dorey, and the other on "Power Factor and Tariff," by Mr. Edward Vincent Clark, were read last week before the Institution of Electrical Engineers, but although the meeting was well attended, for the most part the discussion was disappointing. Long ago, when Professor Miles Walker was paying attention to this matter, we expressed the opinion that it was better to endeavour to remove or minimise the main cause of the trouble than to apply a remedy, and since that time there has been material progress in the desired direction. The electrical manufacturers have endeavoured to help the supply undertakings out of their difficulties by developing motors, which, whilst easily started, will work at unity power factor, or will, if necessary, draw a leading current, and so compensate for lagging currents set up by other motors. All the large electrical firms now manufacture so-called induction type synchronous motors, which have been fully described in papers read by Mr. Lawrence H. A. Carr and the late Dr. Kapp. Induction motors built on ordinary lines are at the root of power factor troubles, especially when they are run underloaded. When new consumers are about to purchase these motors, it behoves central station engineers to do all they can to avoid the employment of machines that are too large for the work. There is no better way, in our opinion, of bringing about a general improvement in power factor than that of persuading the large power consumers, at any rate, to employ modern synchronous motors. Unfortunately, such machines are more costly than squirrel-cage or ordinary slip-ring motors, and they are not made for low outputs. Recently, however, the British Thomson-Houston Company has introduced a "no lag" compensated induction motor, which is made in relatively small sizes, as well as for outputs up to 200 or 300 horse-power. No doubt the cost of these machines also exceeds that of the standard motors, and power station engineers may not find it an easy matter to get consumers to adopt them without the help of an attractive power factor tariff, although we feel convinced that these and similar motors, including salient pole synchronous motors, will eventually prove to be a great help to central station engineers who distribute alternating current. In America the Fynn-Weichsel motor, which is also made for relatively small outputs, is apparently meeting with favour, on account of its ability to work without loading the system with wattless current.

Whilst it is impossible to lay down hard-and-fast rules as to how the power factor should be improved, it may be taken for granted that practically every central station engineer with a growing alternating current power-load should strive his utmost to encourage the employment of machines that will work at unity or a leading power factor. As Mr. Chattock remarked in the course of the discussion on Messrs. Dorey and Clark's papers, the power factor problem is more acute in some places than it is in others. At Birmingham, where there is a considerable number of rotary converters working on the alternating-current system, the necessary correction can be made without the use of special apparatus, but it is conceivable that as the alternating-current load grows, and especially if the new consumers do not install unity power factor motors, special steps will have to be taken to raise the power factor. Synchronous machinery of any kind is, of course, advantageous. Exceptionally large rotary condensers have been built in America for the sole purpose of power factor improvement, whilst in this country we are glad to find the tendency is to use synchronous machines which correct the power factor and perform mechanical work at the same time. Another scheme is to fit phase advancers to existing motors It, as we prophesied at the time of its inception, has not met with widespread favour. Indeed, the first firm to make phase advancers has long ceased to do so. Incidentally, if the proposal to standardise frequency is put into practice some of the electricity supply undertakings will have an excellent opportunity of raising their power factors, for motors that are at present causing trouble could be replaced by unity power factor motors, such as those to which we have alluded. With all the foregoing methods of correcting the power factor Mr. Dorey deals, but what he is obviously most interested in is the use of static condensers, which undoubtedly often meet the requirements admirably. It is scarcely conceivable that such a simple and robust machine as the squirrel-cage motor will ever be completely abolished, or, indeed, even the orthodox slip-ring motor. As far as can be seen at present, there will always be room for static condensers, which can raise the power factor of distribution lines, &c., without undue trouble or expense. A very promising field for this class of apparatus would appear to be in connection with rural distribution, a matter that is discussed in the abstract of Mr. Dorey's paper published elsewhere.

From an engineering point of view, the methods of improving power factor are of greater interest than power factor tariffs, which are discussed in both the papers. Mr. Clark, who confines himself exclusively to the tariff problem, argues that where a low power factor is seriously perturbing a supply undertaking, a rational tariff should include a charge for wattless component, and that a charge based on the kilovolt-ampère hours of lagging wattless component consumed, with an equal rebate for leading wattless component taken at time of load is a reasonable basis for such a charge, although not absolutely ideal. The adoption of a tariff embodying such a charge may, in the opinion of Mr. Clark, be arranged without undue complication of metering methods, and without entailing perplexity in the minds of non-technical users of power. A method of metering is described in the paper, whereby with balanced load a three-phase wattmeter may be "biased" to record the total energy consumption plus or minus any desired fraction of the kilovolt-ampère hours of lagging or leading wattless component. It is a pity that the sale of electricity should involve any power factor tariff at all, but if consumers are to be encouraged to utilise apparatus that is desirable from the supply authority's point of view, it is difficult to see how it can be avoided. While we appreciate the difficulties with which those who sell electricity are faced, it is to be hoped that sooner or later it will be universally recognised that the less the consumer is told about power factor and other supply difficulties the better. Some of the proposals that have been put forward with a view to explaining why one user of electricity should pay more for his current than his neighbour are, in our opinion, little short of ridiculous, and are likely to leave the prospective consumer wondering whether he ought to take up a three years' course in electrical engineering or resort to the use of gas.

The Manufacture of Armour Plate.

ON January 15th, M. Baclé delivered his presidential address to the Société des Ingénieurs Civils de France. He took as his subject the manufacture of armour plate, and in what follows we endeavour to give some idea of the principal points in his address.

The president observed first that although the armouring of ships might be regarded as characterising warship construction during the past fifty years, yet its origin could be found much further back. He noted that the Carthiginians, according to Strabo, armoured their wooden vessels, that in the twelfth century naval powers, the Normans, for example, protected certain types of ships, and that the Knights of St. John of Jerusalem employed armoured caracks—for the siege of Tunis—as did the Venetians in the sixteenth century. In 1780 the Chevalier d'Arçon protected floating batteries which were employed for the siege of Gibraltar with bars of iron. But these early devices might be regarded as of an exceptional and makeshift order, and the arming of ships destined to make ocean voyages would never have been considered had not the progress of gunnery in the first half of the nineteenth century made it essential. It was the invention by General Paixhans of the explosive shell which burst on contact, that finally settled the question and opened the ironside era. The La Gloire was laid down in 1858, and was followed shortly afterwards by the Couronne, which was the first frigate built of iron and provided with metallic armour plate. The example set by France was followed by England, and a national contest ensued in the development of armour. In 1861 the La Flandre was given a belt 15 cm. thick at the water line. Four years later ships of the "Ocean" class had a belt 20 cm. thick, in 1872 the Devastation was given 38 cm., and finally, in 1881, the enormous thickness of 55 cm. was reached in the Amiral-Duperré. That figure has never since been passed, and is the last example of the use of iron for armour plate.

With the coming of this great thickness, it was recognised that the limits had been reached, and that since it was impossible to increase the thickness further, means must be found for producing a harder metal. Steel was already in use for many purposes, and even as far back as 1873, attempts had been made to employ it for ship's armour but without much success. However, Creusot persisted in the experiment, and after many years of endeavour, succeeded in producing a successful plate. Whilst that firm was engaged in making armour by the forging of huge masses of steel, the two great Sheffield firms, Cammell's and John Brown's, took up the manufacture of compound armour in which the steel was cast directly on to a backing of iron, the compound metal being then heavily rolled. In 1880 comparative tests were carried out by the French Navy at Gavres on six plates made by different methods, one welded plate by Marrel Brothers, two cast steel plates by Terrenoire, two forged steel plates, one of soft and the other of hard metal, by Creusot, and a compound plate by Cammell's. These tests proved conclusively the superiority of the Creusot and Cammell plates which, although they broke up under the impact of cast iron projectiles, were not, as were the other plates, perforated by them. The Navy, therefore, decided to adopt plates of these kinds, one being made by Creusot and the compound plates by St. Chamond, Marrel, and Châtillon, who acquired licences from Cammell's.

From 1882 until 1891, the Navy accepted either kind of plate indifferently, and the acceptance trials revealed their characteristics. The Creusot plates, regarded from the point of view of comparative resistance, showed a slight superiority over the Cammell plates, but they were unable to break up the projectiles, as the compound plates did when well made, but both kinds of plates broke frequently when submitted to the attack of three projectiles, especially when cast iron shots were replaced by cast steel and later by forged steel shots. Trials carried out between 1884 and 1889 showed conclusively that some new method must be devised in order to overcome this brittleness. As soon as this fact was established steel masters set about the discovery of a metal free from that serious defect.

The qualities demanded were great hardness of the face with malleability of the back—so that the plates might be bent to shape—great resistance to penetration, perfect homogeneity of the entire mass, and absolute freedom from all interior defects. The history of the armour plate industry is to be found in the continuous search for these qualities. In England, John Brown and Co. adopted the Tresidder process of hardening the surface of compound plates, whilst in France the manufacture of steel plates by forging was generally taken up after 1890, when tests carried out at Annapolis showed that Creusot plates made of nickel steel were less brittle and more resistant than plates of ordinary steel. A steel having 2 to 3 per cent. of nickel with some chromium, was produced under the name of "special steel," and was rapidly adopted with minor modifications throughout France, as well as in other countries, as it exhibited a resistance to perforation 12 per cent. greater than that of ordinary steel, and 34 per cent. greater than that of iron; but as it was found almost impossible to manufacture these nickel chrome plates in con-

siderable thickness, they were reserved only for positions where thin plates were sufficient, whilst for heavy plates, steel with a small amount of chromium was used, but cementation of the surface was carried out with a view to breaking the projectiles on impact.

The cementation process was invented by Harvey, and was first tried in America in 1891 at Annapolis and Indian Head. Between 1892 and 1897 Harvey's cemented plates competed in several trials with "special steel" plates. It showed remarkable qualities of resistance and a hardness which broke up the projectiles, but at the same time it was more brittle than the "special steel." The French manufacturers decided therefore to take up the Harvey process and to combine it with the employment of "special steel," and they succeeded thereby in producing plates with a low brittleness and with a perforation figure 25 per cent. greater than that of ordinary steel. Plates of this kind remained in use until 1900, but the arrival of forged chrome nickel shells, which were able to pierce the plates without being broken or deformed obliged armour-plate makers to seek for still further improvement. In 1896, Krupp's had produced a cemented plate containing 3·5 per cent. of nickel, about 4 per cent. of carbon and 2 per cent. of chromium. It was made free from brittleness by careful heat treatment, which produced a hard face at the same time that it left the desirable soft backing. In this process differential heat treatment was used, the front part being raised to 800 deg. Cent., sufficient to allow of hardening by rapid cooling, whilst the back parts of the plate were only raised to 400 deg. Cent. In spite of the difficulties that this process presented, it was rapidly adopted by the armour plate firms all over the world with one exception. The works at Rive de Gier developed and produced in 1905 a special process invented by their late director, Monsieur Jules Marrel. In this process a 4·5 per cent. nickel steel, with ·25 per cent. carbon and ·60 per cent. chromium, was employed. The steel, although less hard than that of Krupp, had the desirable qualities, a porcelain like grain in front and a fibrous texture behind, and the difficult differential heat treatment of Krupp was not required. At trials carried out at Bethlehem in 1913, the Rive de Gier method was proved to be so successful that Ansaldo Brothers decided to adopt it for armour plates for the Italian Navy.

Whilst continuing with the use of the Krupp process French engineers pursued their investigations in a scientific spirit. Amongst them must be mentioned Monsieur Charpy, who discovered in 1902 a new type of special steel which achieved remarkable results. It contained 0·10 per cent. of carbon, 5·5 per cent. of nickel, and an amount of chromium which varied according to circumstances between 0·6 and 2 per cent. This steel showed a high resistance to perforation with freedom from brittleness. Creusot on its side examined the use of molybdenum, and at the Paris Exhibition of 1900 showed a plate with the chromium content as high as from 3 to 4 per cent., which proved to be as good, if not better, than Krupp's cemented plate. But the capped projectile then appeared and introduced a new element into the never-ending conflict between the projectile and the armour plate. As it reduced the efficiency of cementation, it seemed to indicate that the desirable steel would be a homogenous metal, not cemented, yet as hard as the cemented plates. The war of 1914 came to stop these researches, and in France, at all events, they have not yet been taken up again.

To outline the progress in a few words; if we consider a plate of 200 mm. thickness attacked by a gun of 194 mm. calibre, we see that quite a large plate gave a speed of perforation of 385 m., which was raised to 471 m. when iron was replaced by ordinary steel. With "special steel" the speed rose to 528 m., corresponding to a plate of 360 mm. thickness, that is to say, increased the resistance by 65 per cent. When this metal was cemented the speed of perforation was raised to 612 m., giving a coefficient of 1·60 with respect to iron, and of 1·30 with respect to ordinary steel. With still more recent steels with a thickness of 280 mm., the speed of perforation, with uncapped projectiles, attained about 700 m., that is to say, a plate of iron offering the same resistance would have to be 512 mm. thick.

In the continued search for improved steels for armour plate, great factories have converted themselves practically into laboratories, where the work was carried out with that strictness and exactitude which was so well shown by Monsieur Charpy in the St. Jacques workshop at Montluçon. These studies had useful results in many other directions, and are reflected in the development of steels for railways, marine engines, electrical apparatus of all sorts, automobiles, and even for the flying machine. It should never be forgotten when we watch the wonderful developments of engineering of recent years, that it is due in no small measure to the scientific researches which were carried out originally on the production of war material.

THE Harrogate–King's Cross Pullman train, having been seriously delayed by signals north of Retford, recently secured a punctual arrival at its destination by covering the 139 miles between Retford and King's Cross in 135 minutes,

Literature.

Beiträge zur Geschichte der Technik und Industrie. Edited by CONRAD MATSCHOSS. Vol. XV. Berlin, 1925. 22·5 R.M.

THIS, the fifteenth, annual volume of contributions to the history of technology and industry issued by the Association of German Engineers, is devoted to the industries of the Rhineland, and contains a number of important and interesting articles. Among them we note one on the history of the brass industry in Aachen and Stolberg, by Dr. R. A. Peltzer. The author remarks that we have no certain knowledge when brass was first used, but that in any case it was known to the Romans and that the oldest known objects of this material are Roman coins. Recent research makes it very probable that there were brass works in the Roman province of Germania, and in the calamine mines round Stolberg Roman remains have been found. Aachen (Aix-la-Chapelle) is within easy reach of the celebrated Vielle Montagne mines, and Stolberg, about 6 miles east of Aachen, has mines in its vicinity. In the old process of making brass zinc was not used in the metallic state—the ore, calamine, was combined with the copper. This implies that a greater weight of calamine was required than of copper, hence the close association of the brass works with the calamine mines. The documentary history of brass making in Aachen is carried back to the year 1450, when Daniel van der Kammen, a stranger, with his men, in association with a burgess of the town, one Konrad Duppengiesser, established works. The documents distinctly mention copper and calamine as the raw materials. The growth of the industry was much accelerated in 1466, when the town of Dinant was razed to the ground by the Duke of Burgundy and many of its inhabitants sought refuge in Aachen. Dinant, it is perhaps unnecessary to say, was widely celebrated for its coppersmiths. No doubt, as a result of this migration, Walloon terms are found to be very common in the Aachen brass trade, and in the records many of the coppermasters bear Walloon names. In spite of the extensive use of brass, the term "copper" was used for both copper and brass in the Aachen district as well as in Flanders and Holland, the idea being that the addition of the calamine merely changed the colour of the copper and not its substance. The word "Latoen," corresponding to our "latten," was, however, in use.

By the middle of the sixteenth century the manufacture of brass and brass wares had become the most important industry of the town. In 1581 1000 men were employed in it, and the production, including wire, pans and other beaten goods, was at least 30,000 cwt. annually. This is probably the high-water mark of the Aachen brass trade.

The makers were associated in a guild, and by the guild regulations each master was limited to the ownership of two furnaces. To deal with the output of two furnaces he required two hammer mills, and, in all, he employed seventeen men. It seems that from the earliest date, 1450, hammers driven by water wheels were employed, but their use was restricted to beating out the cast plates into sheets; it was forbidden to use water-driven hammers for shaping the sheets into pans, kettles, &c. The plan of hammering a number of superposed sheets into pans simultaneously, the author thinks, originated in the Aachen district at the beginning of the sixteenth century. It was in use in Stolberg soon after.

The restrictions imposed by the guild regulations, together with political and religious troubles, led to the gradual transfer of the industry from Aachen to Stolberg. Stolberg had no guilds, there was abundant water power, wood and ore on the spot. By the year 1648 it had 65 furnaces, while Aachen had but 50. In the eighteenth century there were 130 to 140 furnaces, over 100 hammer mills and wire-drawing shops, and the production of brass in various forms was 40,000 cwt. annually. The industry throve until the end of the eighteenth century; decay then set in, but it does not appear that the trade died out, for we are informed that Stolberg still has brass works, whose ascertained history goes back 400 years. When the industry ceased at Aachen is not stated, but it may be remarked that John Ray, in the course of his travels in 1663, saw brass being made there, and Houghton in 1697 refers to the "great brass works of Acon or Aix la Chapelle." That writer, in describing the manufacture of brass in England and in connection with stone moulds in which the plates or ingots were cast, states that they came from St. Malo, from whence the works at Aachen were likewise supplied. The paper is accompanied by sketches from engravings by a Nuremburg artist, at the end of the 17th century, showing the foundry, the coppersmith, water-driven hammers, wire-drawing, and polishing.

A paper on the iron industry in the North-West Eifel deals with the works in the Eschweiler district, between Cologne and Aix-la-Chapelle. It seems that the puddling process was introduced here so early as 1824. About the same time a wire mill, "according to the English fashion," was set up, mainly with the object of supplying the textile factories of Aachen with card wire. This is stated to be one of the oldest wire mills in Germany. It is interesting to recall in this connection that about 250 years earlier German workmen were brought over to erect and work a wire mill at Tintern, in Monmouthshire—the first in England for drawing wire by water power. Previously wire had been drawn by men's strength.

Another paper deals with ironmaking in the neighbourhood of Treves. It is accompanied by reproductions of curious old drawings of blast-furnaces and hammer mills.

The production of swords at Solingen is known to go back to early times; a paper on the subject carries the industry back to the time of Charlemagne, and even to the fourth century, so that it would appear probable that it was carried on in Roman times and still earlier.

There are two papers on the glass industry. Dr. W. Lauer writes on the industry in the Saar district. It originated in 1616, when the Lorrain "gentilhomme-verrier" Jacque de Titry received permission to erect a glass house. The country was well wooded, so that fuel was abundant, suitable sand was to be had, and potash was furnished by the numerous potash furnaces. Until the beginning of the nineteenth century it was the practice to work the furnaces for a few months only at a time. The use of coal seems to have commenced in 1731, and in 1872 the Siemens furnace was introduced. The second paper, by Dr. Arthur Schröter, is on the plate-glass industry in the Rhineland. The art of casting glass upon a metal table was invented by a Frenchman, Louis Lucas de Nehou, in 1688, but it was not introduced into Germany until after 1850. The first manufactories were at Aachen and Stolberg. In 1860 there were two works in Germany, making together 70,000 square metres of polished plate glass annually. To-day there are nine, capable of producing 2½ million square metres. At first the time taken from the mixing of the raw materials to the completion of the polishing of a plate amounted to 144 hours. To-day the entire process is performed in 36 to 40 hours. Polished plates are made as large as 4 m. by 6 m.

The sugar industry and the manufacture of velvet form the subjects of other papers, and there is a long article on brown coal mining, with illustrations from old drawings. A more modern subject is that of boilermaking. The paper on this subject has drawings of the Walther, Steinmüller and Büttner water-tube boilers at different stages in their development.

The supply of the Rhineland with gas, water and electrical energy, with special reference to long-distance supply, is dealt with in a well-illustrated article.

The volume opens, after a sketch of Rhineland history in general, with a valuable article of some length by Dr. W. Däbritz, dealing in a comprehensive manner with the "Origin and Growth of the Rhine-Westphalia Industrial District." From it and from the contents of the book as a whole, we come away with a profound impression of the amount and nature of the work that has been done, say, within the last fifty years, in raising Germany to the rank that it has attained among the industrial nations of the world.

SIXTY YEARS AGO.

SIXTY years ago tramways, or street railways as they were frequently called, were just about to enter their period of practical development. During the 'fifties tramways had been laid in America and France, and in 1860 Train, an American, laid a tramway at Birkenhead and soon after another one in London. In these early systems the rails were 3in. to 5in. wide, generally with a flat surface for most of their width and an upstanding flange along the outer edge. In most cases it was intended that the rails should be available to all types of vehicles and not confined solely to the use of tramway cars. The London system lasted but a few months. Following numerous accidents it was indicted as a public nuisance and was removed. The Birkenhead system excited equal complaint, but was saved by being relaid with an improved form of rail carrying a groove and devoid of a flange. Although the atmosphere was one of discouragement, many people continued to believe in the virtues of the tramway. The key to the whole problem lay in devising a satisfactory form of rail, one that would not interfere with the ordinary street traffic, either when newly laid or subsequently after it had settled and become worn. In our issue of February 9th, 1866, we gave some particulars of a plan proposed by John Noble and Company, a plan embodied in a Bill for the construction of tramways in London, which was about to be brought before Parliament. Noble's system foreshadowed the modern method of devising the track solely for the use of tramway cars with flanged wheels. The rail—known as the "Crescent rail"—had a narrow flat top and flat sides sloping gently outwards. It was to be laid with its top flush with the surface of the road, and the flanges of the car wheels were to be accommodated in the vee-sectioned groove between the sloping sides of the rails and the faces of the stone setts laid against them. We were at no pains to disguise our dislike of this system. We objected to it on the ground that it would not permit the tramway driver to turn his car off the rails if he wanted to do so, either to avoid a collision with another vehicle or to get in front of another car that had broken down. In addition, we argued that while the groove for the flange would at first be too narrow to allow the wheel of an ordinary vehicle to enter it, wear of the stone setts would quickly widen it to a dangerous amount. Moreover, we foresaw that the groove would become choked with dirt and stones. On the whole, we advocated a system employing rails consisting of slightly concave plates, 10in. to 12in. wide, laid with their edges flush with the road surface. The wheels of the cars were to have tires having a sharply convex tread. Such rails, we argued, would be available to all classes of vehicles and would enable the tramway cars to leave them for the ordinary road surface at any time and at any point. The real development of tramways in this country began two or three years later, the form of rail adopted being in general respects that with which Train's Birkenhead system was relaid as mentioned above.

The Brugg Sub-station of the Swiss Federal Railways.

THE simplicity of the continental electric railways working with high-pressure alternating current must appeal to all who dislike complication, and who aim at carrying work out in the most straightforward manner. Not only does the high pressure on the overhead wire considerably reduce the number of sub-stations, but it also permits the use of relatively simple and cheap sub-station apparatus, which is often erected in the open. The Brugg sub-station of

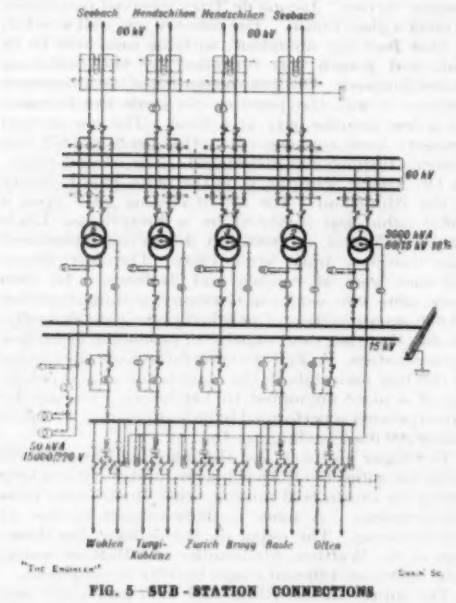


FIG. 5—SUB-STATION CONNECTIONS

the Swiss Federal Railways—shown in Fig. 1 on page 184—forms a good example of this practice, which is quite common on the Continent, and which is coming more into vogue in this country in connection with ordinary electric power schemes.

The sub-station has been erected on part of the ground reserved for a coal depôt at Brugg, and is situated to the south-west of the railway station, to which it is connected by a siding. It supplies the railway lines running towards Zurich, Olten, Basle and Rothkreuz, and to Koblenz, *viâ* Turgi, and also meets the requirements of the Brugg railway station. Single-phase transformers connected to the overhead lines—consisting of four conductors—reduce the pressure from 60,000 to 15,000 volts. From the

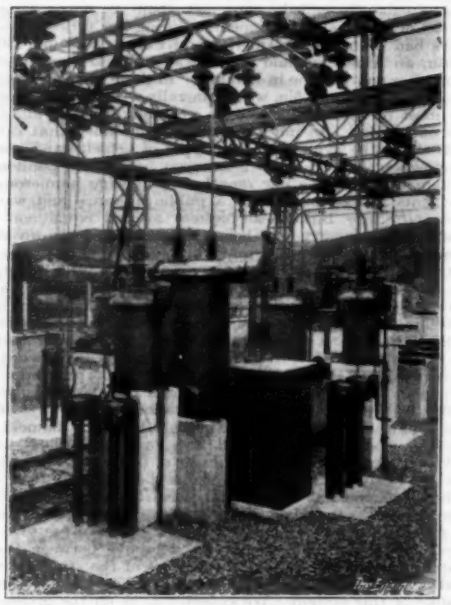


FIG. 6—15,000-VOLT OIL SWITCHES

diagram of connections—Fig. 5—the general scheme will readily be understood. At present the sub-station is supplied from the Amsteg power station of the Swiss Federal Railways, the energy being conveyed by way of the Steinen sub-station and the switching stations at Rothkreuz and Hendschken. At a later date the Brugg sub-station will also be supplied from the sub-station at Rupperswill, which will be connected with the power stations at Vernayaz or Barberine, *viâ* the sub-stations at Kerzers and Puidoux, by means of a 132-kilovolt transmission line. It will consequently be possible, when necessary, to supply the Brugg sub-station from the power station at Amsteg as well as from the station at Vernayaz. The incoming 60,000-volt overhead line may be connected to either of the two sets of bus-bars shown in the diagram—Fig. 5.

At present the sub-station has three transformers, each having a ratio of 60,000/15,000 volts, and a capacity of 3000 kilovolt-ampères, the periodicity being 16⅔ cycles. A view of the transformers is given in Fig. 2 on page 184. In addition to the two 60,000-volt incoming lines from Hendschiken, there are also two outgoing 60,000-volt lines running to Seebach, two supply lines to Zurich, two to Olten and the Brugg railway station. When the station is completed there will be five transformers, one of which will serve as a spare. As shown in Fig. 5, the natural point of the high-tension windings of the transformers is earthed through a resistance and a current transformer, which serves to trip the oil switch in the event of a short-circuit to earth. On the low-tension side the arrangement is naturally different. One pole of the secondary windings is connected to the rails, and the other to the 15,000-volt bus-bar, which is connected to the contact line by means of feeding point switches and testing resistances. The auxiliary transformers are also connected to this bus-bar by means of an oil switch. The function of the feeding point switches is to enable the tracks running to Olten, Zurich, Basle, Rothkreuz and Koblenz to be supplied directly. In the event of an accident to one of these feeding point switches the section concerned can be supplied from the contact wire bus-bars directly. Up to the present, only two feeding point switches have been connected, but the five switches shown in the diagram,

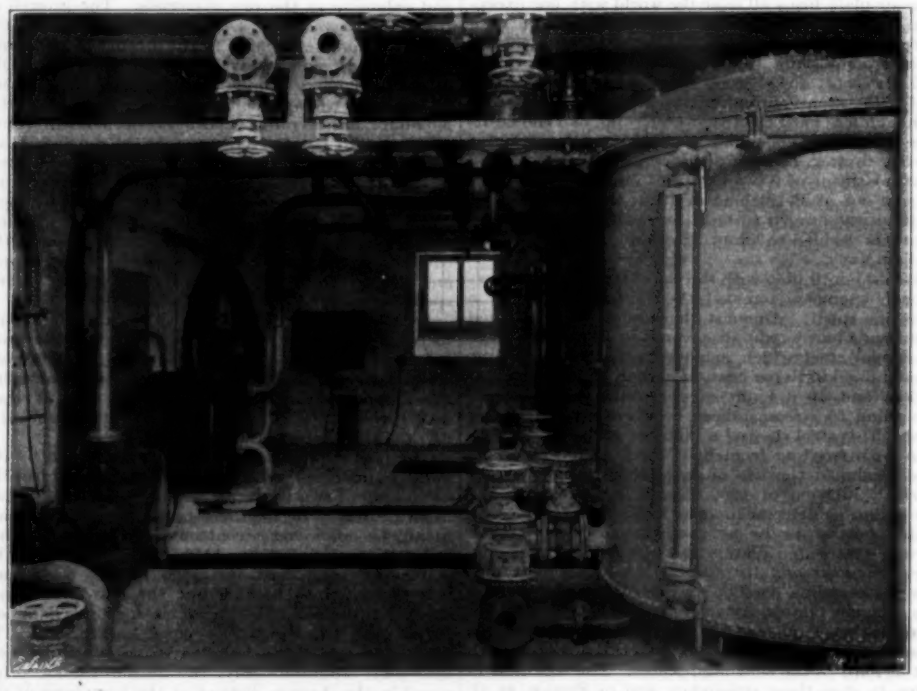


FIG. 7—TRANSFORMER-OIL TANKS AND PUMPS

Fig. 5, will be put into service later. The feeders leave the contact wire bus-bar by way of current transformers and sectionalising switches, and supply the track in each direction, and in the various railway stations the feeders are again united by section switches. Each of the outgoing lines may be earthed by isolating switches. Views of the 15,000-volt single-pole switches are shown in Fig. 6, and in Fig. 4, page 184.

All the transformers and switchgear at the Brugg sub station are erected in the open. Each of the transformers—shown in Fig. 2 on page 184—is capable of giving a maximum output of 3750 kilovolt-ampères for a period of half-an-hour. They are of the natural oil-cooled type, and are provided with the Brown-Boveri patented winding supports. The temperature of the oil and that of the windings is measured with the aid of thermometers with electrical contacts, and in the event of the maximum allowable temperature being exceeded, alarm bells or indicators give warning in the control room. The temperatures of the oil and windings are also indicated in the control room by means of another electrical device. The transformer radiators—see Fig. 2 on page 184—consist of nests of tubes, welded at the top and bottom to the headers, which are attached by means of flanges to the oil tank. As will be gathered from Fig. 2 on page 184, the tanks are mounted on frames fitted with flanged wheels, thus permitting the transformers to be transferred on to rails of normal gauge. Oil-tight conservator or expansion chambers fixed to the tanks prevent oxidation of the oil, and provide accommodation for its increased volume, when heated. A gauge which can be read at the ground level shows the height of the oil in the tank, and a similar indication is also given in the control room. The air pressure in the conservator is compensated by a "breather" provided with an air drying arrangement, which consists of a cylinder containing calcium chloride or some similar hydroscopic substance. Each of the transformer tanks is also provided with a safety valve. The porcelain bushings are fixed to the transformers by means of oil-tight flanges, and it is an easy matter to change them when the conservator tank has been emptied. The insulators are filled with oil, and glass vessels on the top provide for expansion of the oil. An effective test pressure of 150,000 volts was applied to the 60,000-volt apparatus for three minutes during rain, whilst the 15,000-volt insulators, which are not oil-filled, were tested at a pressure of 50,000 volts. For the temperature indicator leads bushings similar to the 15,000-volt bushings are used, but they are provided with double terminals. When necessary, the oil in each transformer can be boiled and cleaned in an oil re-conditioning plant. In the sub-station basement there are four large oil reservoirs—see Fig. 7. Two contain clean oil, whilst the others can be connected to boilers, pumps and filters, and to the transformers containing oil that needs to be treated.

All the switchgear containing oil is erected on concrete bases; whilst the lighter apparatus, such as the 15,000-volt current transformers, is mounted directly on the foundations. Each pair of single-pole oil switches with the electrical remote control forms a switch group, and the switches are provided with electrical signalling contacts. A heating element is to be incorporated in each switch to prevent the oil freezing during cold weather. The remote control operating mechanism is placed on the outside of the switch, and is fitted with a free return clutch, but it may, if necessary, be operated by hand. For local operation a push button is provided. The remote control gear is constructed so that a switch cannot be closed on a short circuit.

As shown in the illustrations—Figs. 1 to 4, page 184—the bus-bars and isolating switches are suspended from a metal framework. The conductors, which are carried on green glass insulators, consist of copper tubes, 30 mm. in diameter, and of various thicknesses. The isolating switches are operated by means of balanced rods. The handle which the attendant actuates is placed at a convenient height, and it is provided with a device which indicates the position of the switch and signalling contacts. To test for short circuits on the overhead line, a resistance and current transformer are connected in circuit with the feeding point switch. In the event of a short circuit the full voltage is applied to the outgoing line at fault through the testing resistance, and the ammeter shows whether the short circuit still prevails. The test resistances can carry a current corresponding to twice the normal pressure for a period of two minutes, and they are fitted with a maximum temperature signalling device. To avoid condensation, the current and potential transformers are completely filled with oil and expansion vessels are provided to compensate for fluctuations of the oil level. All the instrument transformers are fitted with earthing terminals, and a drain cock for the oil. The potental transformers are protected by fuses inside porcelain tubes, which are fixed to the iron frame.

Two outdoor transformers rated at 50-kilovolt-ampères, with a pressure ratio of 15,000/220 volts, supply all the power, light and heat needed in the sub-station buildings, and also feed the remote control gear and signalling apparatus through a motor gene-

rator, which gives direct current at a pressure of 220 volts. An accumulator installed in the sub-station building serves as a reserve. There is also a workshop equipped with the necessary tools for the repair of transformers, &c., and a store. All the 15,000-volt and 60,000-volt apparatus was supplied by Brown, Boveri and Co., who also supplied the three 3000-kilovolt-ampère transformers for transforming down from 60,000 to 15,000 volts.

Some Notes on the Welding of Aluminium.*

By EDGAR T. PAINTON.

THE welding of aluminium was for many years considered to be one of the most difficult of arts, and even to-day in some quarters aluminium welding is regarded as a process which requires a long period of training before absolutely and consistently reliable results are obtainable. Training is undoubtedly necessary, for the metal has distinct characteristics of its own which involve a somewhat different technique from that required with steel, cast iron and other metals. However, this special technique is by no means difficult to acquire, for in point of fact aluminium is one of the most readily weldable of all metals. A perfect joint can be made merely by taking two wires, heating the ends in a blowlamp flame until they attain the requisite temperature, and then pressing them together. Such a process is regularly employed in the jointing of wires and rods up to 1¼in. in diameter used for electrical connections.

The fundamental source of difficulty, which for many years prevented the welding of thin sheets and similar forms not suitable for simple pressure welding, is the rapidity with which the metal oxidises, and the toughness and tenacity of the oxide film formed. It is well known that the mere exposure to the air of a piece of freshly cut aluminium is sufficient to cause the formation of a microscopically thin film of oxide on the surface, so thin that it is invisible, but sufficiently impermeable to prevent contact between the metal beneath and any surrounding medium. Thus, solder melted on a piece of aluminium will not alloy with the surface and "tin" the metal unless means are taken to remove the oxide film. Similarly, if small pieces of aluminium are melted on an iron plate they form globules of molten metal enclosed within a tough skin, and will not coalesce until the skin is broken and the clear metal within is allowed to come into contact.

It will be appreciated that in the butt welding process the oxide skin is broken by the pressure applied. The two ends are heated until they actually reach the melting point, and at the correct instant for welding the ends have been reduced to a mass of molten and semi-molten metal held in place and prevented from dropping away by a skin of oxide. On pressing the ends together the oxide bag is burst and is squeezed out with the plastic metal in the form of an irregular collar. The oxide-free metal within comes into contact and solidifies as a homogeneous whole, and afterwards if the collar is trimmed away the joint is undetectable.

In the oxyacetylene method of welding this mechanical process of removing the oxide has its counterpart in the so-called puddling method. The welder proceeds as in the welding of steel, but stops after he has melted half an inch or so and stirs up the molten bath with an iron wire. In this way he breaks the oxide skin and allows the metal to coalesce, and at the same time he scrapes the oxide to the surface. The method is not a satisfactory one, however, because the oxide of aluminium has a higher specific gravity than the metal and tends to sink to the bottom of the bath, and there is therefore considerable risk of oxide inclusions in the solidified metal. It would be too strong to state that it is impossible to obtain a satisfactory weld by this method. For many years the process was extensively practised, and even to-day it has its adherents, but the quality of the weld depends so greatly upon the dexterity of the welder himself that in the author's opinion it would be unsafe to rely upon the process for important work where the strength required is considerable. Apart from this also, the method is slow and therefore costly in gas and in labour. The welder has three instruments to use: his blowpipe, his filling stick, and his puddling rod, and the manipulation of these is not easy. Usually he starts with his blowpipe in his right hand and his filling stick in the left; when he has got a molten bath, he drops the filling stick, transfers the blowpipe to this left hand, picks up the puddling rod with his right hand, and when he has puddled sufficiently he reverses these actions. Obviously this practice is not to be compared with one in which the welder can proceed continuously without a stop from one end of the seam to the other, and this continuous progress can be readily obtained by the use of a flux which removes the oxide chemically. It may be remarked, however, that the puddling process may be useful in an emergency, and for this reason instruction in this process forms part of the training of welders for the Air Force, since they may be called upon to effect repairs in aircraft components in unfavourable circumstances.

The most effective method of removing the oxide is by the use of a flux. While aluminium oxide is chemically inert, it has been known since the beginning of the industry that it can be dissolved by molten halogen salts of the alkaline metals; indeed, it was the discovery that the oxide can be dissolved by cryolite—a natural double fluoride of sodium and aluminium—that enabled the present method of manufacturing aluminium to be developed. Cryolite forms a useful component of many of the present-day welding fluxes, but other fluorides and chlorides are mixed with it in order to vary the melting point, the viscosity of the molten flux, its density and the speed of action. Lithium chloride, for example, is nearly always a component, since it has a very low melting point, and will therefore reduce the melting point of the whole mixture, producing a flux which is liquid and flows freely before the aluminium itself reaches its melting point. An aluminium flux must not be too fluid, however, or under the blast of the blowpipe it will spread and leave on the weld itself an insufficient quantity to perform the work of removing the oxide.

A typical analysis is given in specification No. L13 for Aircraft Materials issued by the British Engineering Standards Association, which is the flux that aircraft manufacturers were required to use during the war. It consists of potas. chloride, 45 parts; NaCl, 30 parts; lithium chloride, 15 parts; pot. fluoride, 7; pot. bisulphate, 3. This is an all-round flux for general purposes, but many different mixtures are on the market which have their adherents. Different welders have different preferences. A man working on very thin aluminium sheet requires a very fluid and very quick acting flux, since his rate of progress along the seam must necessarily be rapid. For the repair of thick castings, however, a higher melting flux is useful, for the melting period is longer, and it is necessary that the flux should remain in position as a viscous coating that not only does it dissolve the oxide originally present, but it also serves to protect the metal from further oxidisation during the melting period.

All aluminium fluxes are hygroscopic, and must therefore be kept in an air-tight boxes, and they should not be stored in large quantities, because, when through continuous opening of the tin the flux absorbs moisture from the air and becomes damp, it loses its efficiency. An improvement in this respect is due to Dr. Briscoe and Captain Richardson, who discovered that the use of a pyrosulphate or pyrophosphate in the mixture prevents the dissociation of the components and hence provides a flux which can be stored for a considerable period without deterioration.

The explanation given is that the rapid action of most fluxes is due to the liberation of hydrochloric and hydrofluoric acids by the interaction of the components under the blowpipe, and it is these acids which attack the oxide. Support is given to this theory by the fact that the most active fluxes contain an ingredient such as a bisulphate which is capable of reacting with the halogens with the liberation of the acids. If the flux becomes damp, however, this action can proceed slowly in the cold, since the presence of aluminium oxide is by no means necessary. If the bisulphate is replaced by a salt of a polybasic acid, halogen acids are only liberated in the presence of aluminium oxide, and hence the flux is only active during the actual process of welding.

Aluminium fluxes should be used sparingly, if only because they are expensive, and the best method is to use them in the form of a varnish on the welding rod. The end of the rod is heated, dipped into the flux, and the tuft which adheres is melted up the welding rod, to form a uniform coating. It is not then necessary to apply any additional flux, for as the rod is melted into the weld the flux will melt with it and run ahead of the flame, and so prepare the metal in advance. The flux is thus applied just where it is required and at a uniform rate.

Aluminium fluxes have a corroding action on the metal, and hence must be thoroughly washed off after the weld is completed. Small articles which are not likely to be damaged by the sudden cooling may be dipped into water as soon as they are welded, when the excess flux will come away cleanly with the slagged oxide. Larger articles which must be cooled slowly should be thoroughly scrubbed with hot water along the line of the weld, when they are cold.

The welding of aluminium is to-day a large and important industry. The possibility of joining pieces of aluminium by a seam which is simply made, but is nevertheless completely reliable, which is subject to no tendency to deteriorate, but which is in fact for all practical purposes equivalent to a continuous unjointed piece of metal, has widely extended that use of aluminium. The lightness of aluminium makes its use for certain motor car parts practically indispensable, but if there were no ready means of repairing castings and a breakage necessitated complete replacement, it might be considered that the advantage of lightness is obtained at too great a cost. In another direction the chemical inertness of aluminium makes it an ideal metal for plant used in the manufacture of foodstuffs, &c., but if manufacturers of such plant had to rely upon rivetting, screwing, soldering and similar methods the value of the metal would be very seriously impaired.

In both cases oxyacetylene welding has been of enormous benefit. Specialists in the process can effect repairs in castings which are permanent and dependable, and indeed they can build up a part equal in every way to a new casting from a mass of broken parts seemingly only fit for the scrap heap. As regards chemical plant also, it is not too much to say that the whole industry is largely built upon welding. The plant used is often of very great size, necessarily made up of a number of large sheets joined together; often it is complicated and requires permanent leakproof joints between tubes and plates and various fittings; and in a vast number of cases the joints must be able to withstand very considerable pressure.

In many of these applications aluminium would be useless unless the welds are not only strong but are consistent—that is, the process of welding must be so far foolproof that carelessness on the part of a welder is not likely to lead to the production of undetectable weak places in an apparently good weld. It is impossible to eliminate the possibility of carelessness in any manual process, but with aluminium welding the use of a good flux so greatly facilitates the work that the worker is relieved of much responsibility. Unskilfulness would be manifested in lack of penetration, excess penetration and the burning of holes, the development of cracks, and so on, but all these faults are obvious on examination, and it can be taken that if a weld in aluminium made with a good flux is perfect to the eye it will be perfect in reality.

The strength of a weld depends upon the type of metal employed. Aluminium is used in both the pure form and in the form of alloys—sheet metal work usually being in pure aluminium, and castings being usually in alloy.

A weld in sheet aluminium will have a tensile strength of 5 tons to 6 tons per square inch, and it is interesting to note that the weld itself may be a little stronger than the adjacent metal. Aluminium sheet is, of course, applied in various tempers, from dead hard with a tensile strength of 10 tons to 12 tons per square inch to dead soft with a tensile strength of 5 tons to 6 tons per square inch. Hard sheet is annealed by heating to about 400 deg. Cent. for a few minutes, and hence the regions on either side of a weld will always have the strength of annealed aluminium, whatever the initial temper of the sheets. At the weld itself the solidified metal is in the cast state, and will have a different structure from the annealed metal on either side, but its tensile strength will also be of the order of 5 tons to 6 tons per square inch. As the seam will have a certain amount of added metal, and hence will be a little thicker than the original sheet, a test piece under tension always breaks at a point an inch or so away from the weld in the annealed zone. The strength of the weld itself can be improved by planishing, i.e., by a slight hammering in the cold. In the cast state the metal has a coarse crystalline structure, but under cold working the crystals become elongated and tend to approach the structure of hard sheet.

These different effects the lecturer illustrated by means of lantern slides. Turning then to the welding of aluminium alloys, he first dealt with the more simple alloys used for ordinary casting work. For practical purposes, he said, these alloys may be divided into two classes, those containing copper only and those containing both zinc and copper. Ninety per cent. of the castings made in this country are made in what is known as the L5 mixture casting about 13 per cent. of zinc with 2½ per cent. copper, while 90 per cent. of the ordinary castings made in America are in an alloy containing 7 to 8 per cent. of copper. Both these alloys are readily weldable by the same methods used for pure aluminium. The same kind of flux is used, and if a filling stick of the same alloy is employed, the finished weld is even more homogeneous with the rest of the work than in the case of pure aluminium—for the metal at the weld is in the same physical condition as the rest of the work.

It is obviously desirable that the filling stick should be as nearly as possible of the same composition as the casting itself, for though it is quite simple to weld a copper alloy, for example, with a zinc alloy filling stick, the resisting weld has lost one of its advantages over soldering, namely, its complete homogeneity. Special welding sticks have been put on the market which are claimed to have peculiar advantages. These sometimes contain large percentages of zinc—possibly as much as 40 per cent.—and in consequence are of low melting point and flow freely in welding. They therefore facilitate the working, but they are liable to lead to deterioration and are not therefore to be recommended.

The welder does not always know the composition of the casting he is called upon to repair, but the country of origin is a useful guide, and, in addition, an experienced welder can differentiate between a zinc alloy and a copper alloy by the fact that the former will give off fumes of zinc oxide under the blowpipe. A stock of L5 and L11 alloy welding rods will cover all normal requirements, for though certain castings may not contain the exact quantity of copper or zinc corresponding with their standard compositions, the difference is not likely to be so great as to cause serious difficulty. For example, an alloy known as L8, containing about 12 per cent. of copper, is employed for certain purposes requiring a dense hard alloy, but the repair of such castings could be satisfactorily made with an L11—i.e., 7–8 per cent. copper—welding stick, while a simple zinc alloy casting could be welded with an L5 welding stick, the small quantity of copper in the latter not being of serious moment.

Another class of aluminium alloy of comparatively recent introduction contain up to 15 per cent. of silicon, with no other addition. Such alloys may be extensively used in the future in view of some rather peculiar properties which they exhibit, and from the welder's point of view they are excellent. They are remarkably fluid when molten, and can, in fact, readily be identified by that property alone. In addition, they are not hot short and hence are not liable to crack owing to contraction effects. It is necessary to use a silicon alloy welding stick, but otherwise no special precautions are necessary.

While the method of making a weld can quickly be mastered, the application of these principles to the practical case of a casting repair can only be successful if coupled with an intelligent appreciation of the possible effects of intense local heating on an object of complicated shape. The effects of expansion and contraction must be carefully examined, since with aluminium their effects may be even more marked than in the case of iron. The amount of expansion with aluminium is greater than with iron, and, moreover, many aluminium alloys are more or less hot short, so that in cooling down they pass through a stage where they are fragile and readily fractured. If no precautions are taken against expansion and contraction effects, therefore, the work may be found distorted or even fractured after it has cooled. The precautions against these effects are well known, and do not differ from those employed with other metals. Preheating is the most valuable of them, either local preheating, or preferably total preheating, and when the weld has been completed the cooling period should be prolonged to twenty-four hours or more. This is done by covering the casting with asbestos and then burying in sand.

There are several reasons for this slow cooling; first, it ensures a uniform rate of cooling for all parts, whether thick or thin, and so prevents the formation of contraction strains; secondly, it removes any internal strains which may have been caused by the intense local heating during welding; and, thirdly, it has a decidedly beneficial effect upon the quality of the metal itself.

While the heating of a hard rolled piece of aluminium sheet causes its softening, it is not so with a casting, and the researches of the National Physical Laboratory have shown that such heating may produce a substantial increase in strength. For example, it is recorded that the tensile strength of an alloy containing 4 per cent. of copper after exposure to a temperature of 450 deg. Cent. for a period of three days was found to have increased from 9.5 tons to 14.9 tons per square inch, with a corresponding increase in elongation of 20 per cent. This remarkable effect is best exhibited with the copper alloys, but with all the alloys the effect appears to a more or less intense degree, and for that reason alone annealing of welds after completion is desirable.

Turning now to those alloys of aluminium which are used in the form of sheet, it should be explained that rolled alloys exhibit the same superiority over cast alloys as a pure aluminium in the hard worked form exhibits over pure aluminium in the cast form. An alloy containing 4 per cent. of copper, for example, when cast in a sand mould would have a tensile strength of about 8 tons per square

* Paper read before the British Acetylene and Welding Association, February 4th, 1926.

inch. When rolled into sheet its strength may increase to 20 tons per square inch, and as this gain in strength is due to the effect of cold working, it will be apparent that a weld in such an alloy sheet cannot exhibit the same strength as the initial sheet. At the weld itself the strength is that of the cast alloy, some 8 tons per square inch; on either side there are zones where the metal is annealed, and in this connection this alloy has a strength of about 11 tons, while in remote parts of the sheet the strength of the original sheet is 20 tons per square inch.

American Engineering Industries.

THE following passages are taken from a report, written by Mr. J. Joyce Broderick, Commercial Counsellor, H.M. Embassy, Washington, D.C., and issued a few days ago by the Department of Overseas Trade as one of its regular publications:—

ELECTRICAL ENERGY.

Statistics of the mean daily output of electric power in the United States afford a good idea of the rapidly expanding use of electric energy in the country. Growth in recent times is shown in the following table:—

(In Millions of Kilowatt-hours.)

Period.	Average mean daily output.
1919	106·7
1920	120·1
1921	112·2
1922	130·6
1923	153·3
1924	161·2
1925 (January to May)	174·2

According to the estimates of the Department of Commerce, the maximum size of generating units has increased from about 100 to 65,000 kilowatts, and the capacity of power stations in about the same ratio. Total production in 1924 exceeded 500 kilowatt hours for each inhabitant of the country, as compared with about 122 kilowatt hours in 1912. The growing employment of electric power in manufacturing is illustrated by the fact that the number of electric motors installed in manufacturing plants in 1923 totalled over 2 million, with horse-power exceeding 22 million, as against 769,000 motors with an aggregate horse-power of less than 9 million in 1914. Figures showing the advance in the use of electricity in private houses are hard to obtain, but since the war the expansion has been enormous, partly because of the dwindling number of domestic servants. This factor, coupled with the rapid rise in urban land values, has driven larger and larger numbers of people to live in apartment houses or in suburban bungalows and small dwellings, where electric appliances for heating, lighting, cooking and a multitude of household uses simplify the domestic problem. It is estimated that there were over 8 million electric irons, 4½ million vacuum cleaners, 3 million electric washing machines, and perhaps an equal number of electric fans in use in private residences in the United States last year. Radio receiving sets had increased by 1924 to 3 million. From 12 to 14 million houses and apartments are wired for electricity, and there are at least 16 million users out of a total of 26 million families. New structures, whether they be private houses, apartment houses, office buildings, shops or factories, are fitted, as a matter of course, with electric wiring. Notable progress is being made in the electrification of older structures, and, still more important, of farms throughout the country. Moreover, the price of current has been generally reduced as the demand has expanded, the cost of production being diminished as well by a strong tendency to concentrate the control of the electric power industry in the hands of a relatively small number of large regional holding corporations. These consolidations are resulting in a much more efficient operation of the various plants, and the economies effected are producing favourable net revenues for the companies, in spite of heavy capital expenditures occasioned by new construction.

The electrical equipment industry is enjoying a period of continued prosperity, with minor fluctuations. In a recent month the total sales of the Westinghouse Company reached the record level of 16 million dollars, while those of the General Electric Company, the Allis Chalmers Company and others showed substantial increases on last year.

IRON AND STEEL.

Figures of the performance of the American iron and steel industry during 1924 are presented in an appendix from which it is observed that the output in almost every branch suffered in that year a decline from the levels reached in the preceding twelve months. This was, of course, a natural result of the lessened activities in the country's industries as a whole, but also, to some extent, of an output of pig iron and steel during 1923 in excess of requirements. The steel ingot capacity of American mills was estimated at about 54 million tons and the pig iron capacity of the blast-furnaces completed and building on December 31st, 1924, at a little over 54 million tons, the average daily capacity of 405 furnaces using coke being 362 tons of pig iron, as compared with an average capacity of 337 tons in 1921. One furnace under construction at the end of the year at Indiana Harbour, Indiana, was designed to have a daily capacity of 700 tons of pig iron.

Apart from these indications of the growing size of the units in the industry, there is little to be added to what has been said in previous reports respecting its organisation and possibilities; but an outstanding feature connected with its marketing practice last year was an important order issued by the Federal Trade Commission putting an end to the custom of quoting steel prices on the basis of Pittsburg mill prices plus freight calculated at the rates chargeable on shipments from Pittsburg to destination. This change of trade method, while disturbing for a time to producers in the Pittsburg area, was welcomed by producers and consumers in other sections, and was accepted by the industry without demur. One practical result of the change, so far, has been to reduce the prices of certain steel products in the western sections of the country.

Another interesting event was an investigation undertaken by the Bureau of Labour Statistics as to the extent to which the twelve-hour day had been replaced by the eight-hour day, and the effect on earnings of steel workers of the reduction in hours of labour. The following table, extracted from the Bureau's report, shows the percentage of employees in various branches of the industry working seventy-two hours per week in 1922 and 1924, and indicates shat the twelve-hour day has been almost eliminated:—

Percentage of Employees Working Seventy-two Hours per Week.

	1922. Per cent.	1924. Per cent.
Blast-furnaces	69	9
Bessemer converters	67	—
Open-hearth furnaces	64	7
Blooming mills	57	3
Plate mills	39	4
Bar mills	16	3

As regards the effect on earnings of the general adoption of the eight-hour day, the Bureau states that "while full-time hours were decreased so materially, wage rates were adjusted so that the employees received but slightly less pay for the shorter shifts than they had formerly received for working the longer hours. Later, substantial wage increases were effected in practically every department, so that the increase in hourly earnings has even more than offset the reduction in number of hours per week, and full-time earnings per week still show an increase in all departments except plate mills."

No figures are yet to hand to show in what exact manner the reduction of working hours has affected the cost of steel production, but it is estimated by the *Iron Age* that the reduction has added 3 dollars a ton to the labour cost of rolling steel. That the cost of labour has become much greater during the last ten years in relation to the other items in the cost sheets may be gathered from reports of the United States Steel Corporation, which indicate that the proportion of the Corporation's gross receipts from shipments of its products which is paid for labour increased by 31 per cent. between 1913 and 1924. Out of each dollar of gross receipts in 1924 a sum of 52·4 cents was paid to labour, in comparison with 39·8 cents in 1913. General expenses in 1924 consumed 22·5 cents from each dollar of gross receipts, depreciation 5·8 cents, taxes 5·3 cents, and bond interest 3·1 cents, leaving 10·9 cents on the dollar for stock dividends.

Production of steel ingots in the eight months ended in August, 1925, is estimated for the whole country at close on 29 million tons, as compared with 24 millions in the same period of 1924. Monthly output, in other words, has been keeping well ahead of the previous year, notwithstanding a continuous decline in the unfilled orders of the United States Steel Corporation, which are usually taken as the best reflection of the demand for steel products in general. Unfilled orders are now—August 31st—at a slightly higher figure, 3,512,803 tons, than they were at this season last year, but are lower than any previous year since 1921. Complaint of the lack of forward orders has been very general for some time, but orders for prompt delivery have been more satisfactory, and stocks are not believed to be excessive. There has been also a slight recovery in the prices of some iron and steel products, notably in the price of pig iron in recent weeks. The number of blast-furnaces in operation at the end of August showed a gain for the first time since February, and the continued high degree of activity in the building, the automobile and other steel-consuming industries, coupled with a freer buying of equipment by the railroads, gives promise of somewhat better business in the steel industry during the remaining months of 1925. Manufacturing plants in general are now operating at about 70 per cent. of their capacity. Tin-plate shipments are running in larger volume than ever before recorded.

The most difficult problem confronting the industry as a whole—and it is equally pressing in most of the other basic industries—is the problem of economical distribution. Keen competition and high selling costs make it difficult for the manufacturers to secure prices that show reasonable profits on their investments.

OCEAN SHIPPING.

Solution of the difficulties of the shipping business is still retarded by the failure of the freight-carrying business to show any really substantial increase in volume, and by the consequent heavy and apparently expanding surplus of available tonnage. The difficulties have been aggravated, so far as liner traffic to the United States is concerned, by the enormous drop in the immigrant passenger business, resulting from restrictive immigration laws in this country.

Gradual improvement in 1924 continued haltingly for a short period in 1925, but was followed by a very unfavourable reaction with a general decline in the freight charter market. The index number of trip charter rates based by the United States Department of Commerce on six tramp ship commodities over twelve world trade routes dropped in June to 95 per cent. of the 1911–1913 average, as compared with a monthly average of 106 per cent. in 1924, and there was also a decline in the index number of liner rates from Atlantic ports of Europe. Idle tonnage in the United States on July 1st, 1925, amounted to 4,253,000 tons, as against 4,233,000 on January 1st. Of the unemployed shipping, only 366,000 tons represented privately owned vessels, practically all of the remainder consisting of the laid-up tonnage of the United States Shipping Board.

The working of the Shipping Board fleet is being carried out at a substantial annual loss, which falls upon the taxpayers. Considerable economies have, however, been effected within the last year or eighteen months, chiefly as a result of the transfer of its practical control to the Emergency Fleet Corporation. Improved administration under what amounts to one-man control and increased efficiency, achieved by the consolidation of competing or overlapping services and by the laying-up of about twenty superfluous cargo boats, have marked the operation of the fleet in recent months.

The Corporation's present conversion programme provides for fifty steamers of the laid-up fleet to be, within the next few years, reconditioned, equipped with Diesel motors, &c. There would therefore be 200 vessels to be replaced at the rate of about twenty a year, and at a cost ranging from 800,000 to 1,500,000 dollars, and averaging in all 20,000,000 dollars a year. In addition, there are fifteen passenger and combined passenger and cargo boats now in commission, whose replacement would cost from 10 to 15 million dollars per vessel, and involve an annual outlay of about 10 millions a year. The resulting business situation may be summarised as follows:—

	Minimum annual cost to taxpayers. Dollars.
1. Continued Government operation of a cargo fleet of 250 ships	10,000,000
2. Replacement of cargo ships	20,000,000
3. Replacement of passenger and passenger and cargo liners	10,000,000

These estimates show a total minimum annual expenditure of 40,000,000 dollars, and seem to be based on the assumption that the passenger and passenger and cargo liners can be run without operating loss. Account must also be taken of the laid-up tonnage, which at present involves a considerable monthly sum for storage and maintenance. The programme would include the sale of a large proportion of this tonnage for breaking up. The President's Committee is said to have suggested that 521 ships in the laid-up fleet might be scrapped, and 200 of them were sold in August for that purpose for a total cash sum of 1,706,000 dollars. The remainder will probably be similarly disposed of before long.

LABOUR.

The employment situation in the United States at the present time reflects the satisfactory conditions generally prevailing in American trade and industry, and is quite favourable on the whole.

The average of industrial earnings is higher than it has been since 1920, because of steadier and more extensive employment. Real wages at the present time are about 25 to 30 per cent. above the pre-war level, and all available figures would seem to indicate that the general trend is slightly upward, but during the past twelve months there has been a movement towards wage reduction in many important trades, particularly notable in the bituminous coal and textile industries. In the former, the owners of unionised mines—operating about 65 per cent. of all the pits in the country—who were parties to the wage agreement signed at Jacksonville in February, 1924, have been unable to meet the keen competition of the non-union mines, and have been forced, in many instances, either to cease operation or to negotiate special agreements at lower rates with their individual working forces. Woollen and cotton textile companies in New England, under the stress of continued depression and slack demand for their products, have made efforts this year to diminish the wages of the operatives by 10 per cent. In some cases the reduction has been accepted voluntarily by the workers, but in numerous instances the proposed changes have led to strikes of considerable duration, and have evoked the active opposition of the United Textile Workers' Union and the American Federation of Labour. At the annual meeting of the latter body, held at Atlantic City, a resolution was introduced on October 7th which, after noting the "serious depression in the textile industry," called upon Congress to investigate whether the existing low wages and unemployment in that industry have been brought about by inadequate tariff protection on its products or by other causes.

Several of the smaller iron and steel companies also have recently attempted to bring a lower wage scale into operation, and a similar attitude on the part of employers is noted in the chemical, the clothing, the building and some other trades in particular localities.

The bargaining position of organised labour is strengthened in these wage disputes, actually and prospectively, by the working of the present immigration laws. During the year ended June 30th, 1925, the total number of immigrants into the United States was only 294,314, as compared with 706,896 during the twelve months immediately preceding, and an analysis of last year's figures shows that there was actually a net loss of over 15,000 in the ranks of unskilled labour in the country. A decade of such losses might have important consequences, and although it is impossible now to forecast the trend of immigration in future years, some anxiety is beginning to arise respecting the supply of common labour, and there is a movement already afoot amongst employers for a modification of the law to permit a larger influx of labourers for the needs of industry. For obvious reasons, no such change in the restrictions imposed by the law is likely to commend itself to the labour leaders.

Discussions at its last two conventions throw an interesting light on some of the present pre-occupations of the American Federation of Labour's membership, which is now said to number about 3,000,000 workers. Resolutions were passed at these conventions dealing with the expediencies of political activity; with the "invasion of private industry by the Government"; and with the efforts of the Government to promote industrial peace on the railroads; with labour banks and insurance companies; with child labour; with the use of the injunction in labour struggles; with group insurance, company unions, &c.

Opposition was expressed to any attempt by the Government to engage in private industry. Possibly, the Federation had in mind the Government operation of merchant ships, but it is not clear what exactly was meant by the resolution.

The Railroad Labour Board, set up in 1920 for the settlement of disputes affecting railroad employees after the return of the roads to their owners, was condemned as not adequately performing the functions for which it was set up.

At the meeting of last November a report was submitted by the Executive Council of the Federation on the subject of recent developments in group insurance. The Council recommended that organised labour should itself engage in joint insurance enterprise, and pointed out that the existing conditions, financial methods and machinery of labour organisations are well adapted to furnish their members absolute insurance protection at the lowest possible cost. The report was adopted and special conferences of union officials have been held during the year to draw up a scheme to give effect to the proposals. No

information is yet available as to the practical progress made in this matter, but the question occupies a prominent place on the agenda of the convention which, at the time of writing—October, 1925—is in session at Atlantic City.

Employers throughout the country have, on an increasing scale, been following the practice, adopted with apparent success by a few of the largest industrial units, of encouraging the formation of special company unions by their own working forces. The spread of this movement is noted by the Federation, as well as that of giving the employees of particular corporations a direct interest in their individual welfare by facilitating employee ownership of the corporations' stock. These practices are apparently to be countered by intensified efforts on the part of the Federation to extend its own membership, and also to proceed with the unionisation of women engaged in industrial occupations.

SIMPLIFIED PRACTICE.

The movement towards simplified practice in industry and trade, and the elimination of industrial waste of various kinds, inaugurated in 1921 by Mr. Hoover, have made remarkable strikes in the last four years and have already resulted in substantial economies in a large number of industries.

A Division of Simplified Practice, established in the Department of Commerce, working in conjunction with the United States Chamber of Commerce, the American Engineering Standards Committee, the American Society for Testing Materials, the Society of Automotive Engineers, the American Institute of Architects, and numerous other expert trade bodies, and assisted by the active sympathy of trade and technical periodicals, has been instrumental in bringing together representative groups of producers, distributors and consumers in various lines of manufacture and in inducing them, after comprehensive investigation of output and sales, to agree upon the voluntary reduction of sizes, types, styles and patterns which had grown excessively numerous and varied under the influence of unregulated competition. Some idea of the actual progress made may be obtained from the following typical achievements recorded by the Department of Commerce in various groups of industries :—

Iron and Steel Group.—At a conference held in October, 1924, the reduction of sizes and gauges of sheet steel from 1819 to 263 was decided upon.

In the machine tool branch a resolution effective on July 1st, 1924, reduced by 46 per cent. the number of forged tool models and varieties.

Manufacturers of files and rasps, confronted with similar problems of excess variety a few years ago, undertook, with the concurrence of the distributing trade, a reduction in sizes and types from 1351 to 496.

At the end of the year surveys were being conducted of the variety and demand in machine knives, tool steel and various other items.

Sizes and varieties of woven wire fencing have been cut down in number from 552 to 69, and sizes of packages for this commodity from 2072 to 138.

Construction Materials Group.—After several conferences held by representatives of various groups in the lumber industry for the purpose of developing more uniform practice, both as to definitions of basic grades and as to standards of size, a programme was adopted in May, 1924, reducing by 60 per cent. the softwood standards. Additional progress in the softwood field was recorded a year later. At the end of 1924 the standards for hardwoods were under consideration and also a programme of simplification of sash, doors, millwork, &c. Progress in reducing varieties of other construction materials is summarised by the Department of Commerce in the following paragraphs :—

"Up to January, 1924, simplification practice recommendation had been adopted in the following industries allied with the construction industry :—Vitrified brick, metal lath, asphalt (penetrations), common brick, smooth face brick, rough face brick, hollow building tile, structrual roofing, and blackboard slate.

"In 1924 simplification was extended to the following :—Brass lavatory and sink taps, builders' hardware, asbestos paper, hot water storage tanks, concrete building units, steel reinforcing bars, structural and roofing slate, and hollow building tiles. At the close of the year programmes of simplification were nearing completion in the sand lime brick industry, and surveys were well under way in a number of items entering into building equipment, notably copper range boilers, elevated steel tanks and towers, cold water storage tanks, combination boilers and gas water heaters, warm air furnaces, screen wire cloth, and stores. The adoption of simplification will definitely contribute to the reduction of manufacturing costs, and, with the resultant saving passed on to the consumer, should be an important factor in lowering construction costs."

ONE of the outstanding features of the practical application of the recommendations made by the Rock Drills Committee, appointed by the Rand Mines Central Mining Group over two years ago, has been the very considerable economies effected in the use of drill steel, explosives and compressed air, particularly as regards explosives, and one company at least admits a saving of 3s. 10d. per ton mined during the past eighteen months in this direction alone. As an illustration of what has been done recently, the record of a stoper on the Far East Rand is interesting. This miner in September last obtained 280 square fathoms in twenty-two shifts, and used twenty-six cases of 50 per cent. gelatine, with two 45 lb. jackhammers, and only four machine boys. That is, he obtained 6.34 fathoms per machine shift and 10.8 fathoms per case of explosive. On top of that must be noted the great difficulties of efficient lashing and tramming on the flat mines of the Far East Rand. This is not by any means an isolated instance; in fact, it is becoming quite a general occurrence, so much so that no comments are made on stoping efficiencies of between 6 and 7.5 fathoms per machine shift. During October one miner is reported to have obtained 319 fathoms with two light jackhammers. His output was 8 fathoms per machine shift, but the quantity of explosive is not given.

Obituary.

GORDON H. FRASER.

THE death is announced of Mr. Gordon H. Fraser, managing director of the Pearson and Knowles Coal and Iron Company, Ltd., of Warrington, as having taken place on Wednesday, February 3rd, following an operation in London. Mr. Fraser's connection with the Pearson and Knowles' group dated from 1920, when Sir W. G. Armstrong, Whitworth and Co. acquired their controlling interest, but for some years prior to that date he had been associated with the manufacturing side of the trade as chairman of Burnell and Co., Ltd., while his earlier connection with Mahler and Co., Liverpool, had brought him into close touch with every section of the iron and steel trade. He was also a director of Rylands Brothers, Ltd., of Warrington; the Partington Steel and Iron Company, Ltd., of Irlam, Manchester; the Moss Hall Coal Company, Ltd., of Wigan; and the Wigan Junction Colliery Company, Ltd., of Wigan. In addition, he was chairman of Burnell and Co., Ltd., Ellesmere Port, and of Kitchen's Reversing Rudder Company, Ltd., Liverpool.

Mr. Fraser was deservedly popular with all classes in the trade. Though of a quiet and retiring disposition, he had a very keen insight and a personality which gained for him the deep respect and affection of everyone with whom he associated, especially his fellow directors, the members of his staff, and the rank and file of the workers. In addition to his close association with local charities, he was exceedingly sympathetic to everything appertaining to the welfare of his men, and took the deepest interest in a very large number of individual cases of hardship and suffering.

THOMAS W. WARD.

WE record with regret the death on the 3rd inst. at his home, Endcliffe Vale House, Sheffield, of Mr. Thomas W. Ward, the founder of the firm of shipbreakers which bears his name.

The story of Mr. Ward's business life is both a romance and an example of commercial endeavour. His success was achieved from small beginnings. There was a time when business men looked with suspicion on the scrap iron merchant, and the second-hand machinery business, but by sheer honesty and square trading the late Mr. Ward lifted his business and the whole trade to a pinnacle which commanded the respect of the industrial community. He commenced business in 1877 at the age of twenty-four as a coal, coke and iron merchant, and in a few years became an important factor in the iron, steel and allied industries. As the business progressed he added the sale of machinery to his activities, extending the area of his operations and eventually dealing in obsolete works and battleships.

In the course of his business Mr. Ward travelled a great deal, visiting America, South Africa, Australia, and most countries in Europe. He gave evidence before the Railway Commission in 1914 and assisted at other Commissions of national importance. In 1913 he had the unique honour of serving as president of the Sheffield Chamber of Commerce and Master Cutler, both at the same time. For many years he was a Justice of the Peace.

THOMAS HENRY TREGONING.

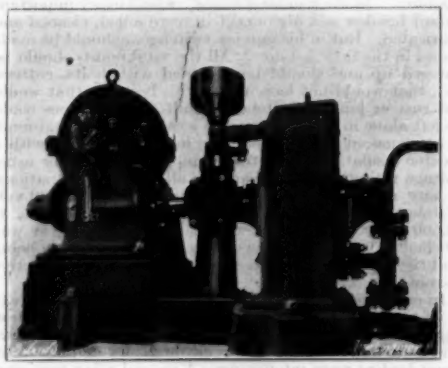
THE death at Illogan last week of Mr. Thomas Henry Tregoning, at the age of ninety-three, robs Cornwall of an able engineer and draughtsman of the old school. He had spent all his life in the foundry trade in West Cornwall, which was his native place. About forty years ago he invented what is known as the dipper wheel, which is still used in raising tin-bearing slimes from mine streams. Prior to its introduction the slime was lifted by boys with shovels and scoops. He was also associated with Michell's and Tregoning's patented pulveriser, from which the tube mill now in use developed. Both these appliances marked a distinct advance in mining methods, facilitating the work and making it more thorough. "Captain Tom," as Mr. Tregoning was popularly known, had as a business colleague for some time Captain W. J. Hocking, of Camborne, but his last working days were spent as manager of the Redruth Foundry Company.

A New Hydraulic Governor.

ON the occasion of a recent visit to the East Greenwich works of the South Metropolitan Gas Company, we had an opportunity of inspecting, at work, the little Pelton turbine, illustrated by the engraving below, which is noteworthy on account of the means adopted for governing its speed.

This turbine is employed for driving a coal elevator, and is mounted right up at the top of the boiler-house. As it was originally installed it had no governor, and some trouble was experienced on account of racing when the load on the conveyor fell off, and a man had to stand by the throttle to check the machine on such occasions. The turbine has, however, been fitted with governing gear, by Mr. Percy Pitman, of 25, Victoria-street, Westminster, and can now be left to take care of itself, the variation in speed between full load and no load being only 3 per cent.

The governor controls the turbine by deflecting the jet from the wheel according to the load on the machine, which is, of course, a well-known principle; but the deflector is quite novel in form. As will be seen from the line drawing, it is arranged directly in front of the nozzle, and embraces the jet, instead of being above it only, as is generally the case. It will also be noticed that there is a slight constriction of the passage through it towards the outlet end. The result is that when the deflector is rotated by the governor the jet is split by the two edges and is diverted from the wheel in two separate streams—as shown in the drawing. The proportions of the various parts are such that the reactions of the two streams on the deflector are equal, and, as they act on opposite ends of the diameter, they balance one another and the deflector is in equilibrium in all positions. It is obvious that such an arrangement is a great advance on the type

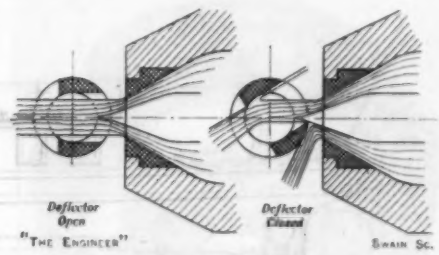


3 B.H.P. PELTON WHEEL WITH GOVERNOR

of deflector which is unbalanced and requires considerable force to withstand the reaction of the jet. The Pitman deflector can, in fact, be easily operated by hand and can consequently be directly connected with a governor of the ordinary centrifugal type.

As will be seen from the engraving, the governor is mounted on a pedestal between the Pelton wheel casing and the speed reduction gear-box. It is driven by silent skew gearing running in an oil bath, and is connected with the deflector spindle by means of linkage having ball joints. The wheel is capable of developing 3 brake horse-power when running at 1630 revolutions per minute, and supplied with water at a pressure of 700 lb. per square inch. The jet is approximately $^{7}/_{32}$in. in diameter. The skew gearing of the governor reduces the speed to 815 revolutions per minute, and the main gear-box brings the speed of the driving shaft down to 50 revolutions per minute.

In the case of the machine under review no attempt has been made to vary automatically the size of the jet to accommodate the load, after the deflector has taken care of the momentary fluctuation. The adjustment is instead made by hand by moving the needle backwards or



ACTION OF PITMAN DEFLECTOR

forwards in the nozzle. Mr. Pitman has, however, devised a simple form of oil-operated servo-motor for this purpose, which is also controlled by the same governor. In such cases a dashpot is arranged between the governor and the needle operating gear to give a slight lag between the abrupt movement of the deflector and the gradual closing of the needle, in order to obviate any liability to shock in the water supply piping. With this arrangement the efficiency of the set is naturally improved, as only sufficient water is taken from the main to meet the demands of the load. In the case of a 35 horse-power unit recently set to work Mr. Pitman has, for instance, guaranteed an efficiency of 79 per cent. at full load, 80 per cent. at three-quarter load, and 78 per cent. at half load. In this machine the buckets are of manganese bronze, ground and highly polished inside, and are secured to a steel disc runner by fitted steel bolts. The bearings are bronze lined, and have ring oiling arrangements. The shaft is Siemens-Martin steel, while the needle tip, nozzle, and deflector are made of stainless steel. The quantity of water used on full load is 9 gallons per minute and the mean contraction of jet is 10 mm.

ACCORDING to a recent Tasmanian Government report there are coal seams along both sides of the route from Lake St. Clair to within 20 miles of Gormanston, and silver-lead lodes in the valley of the Canning River, a region which has never been properly explored owing to inaccessibility. There are also copper lodes of low grade and large extent, and in the Boyes River country and Prince of Wales range there are osmiridium deposits. Tin lodes and alluvial deposits of a large extent are stated to be present in the Canning and Sophia Rivers.

Institution of Electrical Engineers.

AMERICAN SWITCHGEAR.

AT an informal meeting of the Institution of Electrical Engineers held on January 28th, Mr. W. H. Clothier opened a discussion on switchgear. Dealing with a recent visit to America, he said that 30,000 or 40,000-kilowatt turbines were common in the United States; 50,000 to 60,000-kilowatt sets were quite numerous. A 75,000-kilowatt machine was on order, and one of 100,000 kilowatts capacity was contemplated. At Chippaw there were eight 50,000-kilowatt sets and there was room for another set of the same output. Steam power stations of 250,000 kilowatts capacity were quite common, and future schemes involved the erection of stations of 600,000 kilowatts capacity. On one system there were about 100 stations operating in a densely loaded area, and thirty to forty men were engaged solely on routine examination and cleaning. In the regular quarterly round every important circuit breaker was disconnected, overhauled, cleaned and lubricated. But in his opinion switchgear should be made sound in the first instance. All the vital points should be covered up and should be provided with bolts, cotters, &c., that would not loosen and with bearings that would not rust or jamb. Switchgear built on those lines could be left alone in the same way as a cable laid underground. It was customary in America to install apparatus with a greater insulation factor than that provided by the usual voltage rating of switchgear. In all important situations, at any rate, that practice was noticeable; 25,000-volt switchgear, for instance, was in use in power stations at 13,500 volts. In a paper mill 2300-volt switchgear was labelled 15,000 volts on the danger notice, the reason being that the higher voltage was supposed to be a more effective warning.

In order to maintain the necessary steadiness of voltage at the consumers' terminals, motor-operated induction regulators were used on the 2300/4000 radial feeders. The automatic re-closing circuit breakers employed on those feeders were interesting. A special relay was used to prevent re-closing on a bad short-circuit, but otherwise the breaker would close twice and then lock out. It was interesting to note that 50 per cent. of the faults cleared at the first shot, 25 per cent. at the second, and the remainder looked the circuit breakers out. The general practice was to close three times before the final lock-out occurred, the time interval increasing successively from, say, five to twenty and forty seconds. American circuit-breaker design was not yet stabilised, but most of the breakers for 750,000 to 1,500,000 kilovolt-ampères were installed in steel tanks, which were earthed. Sundry features indicated an endeavour to increase the breaking capacity of circuit breakers. In one case explosion pots surrounded the two breaks inside a strong tank. In another case there were four breaks in series and two tanks, one inside the other, the inside tank being free to telescope downwards against springs, thus allowing a certain amount of expansion of the internal volume. On visiting in large American stations the fact was revealed that in no two stations was the circuit breaker construction exactly alike. Going from Tyneside, where the lighting was reasonably steady, where there are practically no reactances and where the network is all solid, one could not help wondering to what considerable extent the American engineers had been forced to the use of regulators by the greater use of reactances, and the system of radial feeders. In one place visited it was impossible for the engineers to guarantee the voltage at the consumers' terminals within 12½ per cent. without the use of the regulators. Continuing the discussion, Mr. H. Trencham said that one very important difference between English and American practice was that in the latter case the power company's engineers were entirely responsible for the lay-out, whereas in this country the consulting engineers and contractors had to bear the responsibility. Mr. A. F. Harmer said that in order to secure an extensive development of electricity it was essential to cheapen sub-station gear. Mr. Ferguson believed Mr. Clothier to be correct in assuming that British principles relating to armour-clad switchgear would extend in the United States. He also thought that developments in this country would compel British engineers to adopt the practice of making extensive use of reactances. Messrs. R. C. Anderson, G. M. Davies, Lieut.-Colonel K. Edgcumbe, M. D. Hart, D. Kingsbury and C. Lipman (who occupied the chair) also spoke.

THE PROPAGATION OF RADIO WAVES.

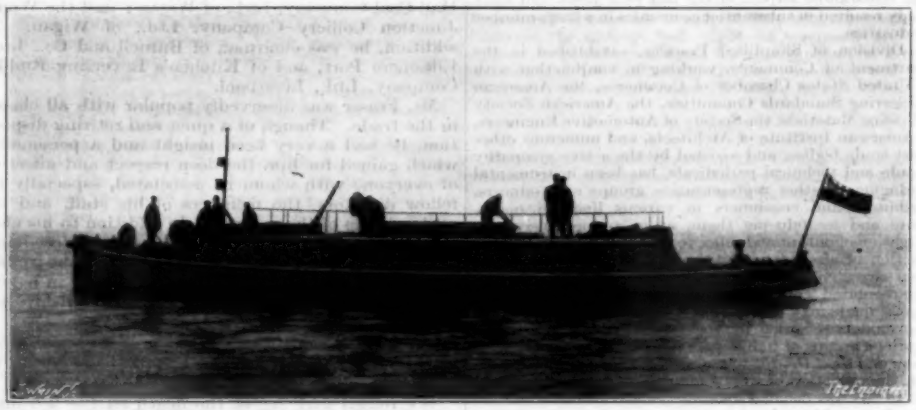
In a paper on "The Propagation of Radio Waves," read by Mr. J. Hollingworth before the Wireless Section to the Institution, on Wednesday, February 3rd, the results are given of a systematic study of received intensities of various long wave wireless transmitting station over a period of nearly two years. The weekly averages of the results are studied, and it is shown that they are inconsistent with any law of steady decay. The results also show very marked periodic variations. It is suggested that all the observed effects can most easily be explained on the assumption of an upper refracting layer; this being supported by the results obtained by plotting an intensity distance curve in detail, with the aid of a portable set, and by the study of the systematic changes which take place daily during the period of sunset. Various conclusions are drawn from the results, but it is considered that considerable additional experimental investigation of many of the observed phenomena is necessary. The experiments differed from the majority previously carried out in that the distances were comparatively short. Simultaneous observations were made whenever possible, and only daylight transmissions were considered. In the opinion of the author, comparatively short distance work offers an opportunity for reducing the uncertainty with regard to some of the independent variables, and it seems reasonable to suppose that there is a chance of natural phenomena being more constant over small areas than over large ones. Short distance work also removes the difficulty of the path containing day and night sections.

The author's conclusions are that:—(1) Long-wave signal intensities over medium distances (< 1200 kiloms.) remain extremely steady over the period May to September during daylight hours. (2) Their distribution does not correspond to the Austin-Cohen formula for anything less than yearly averages, in which case the distance is not large, and the law of decay is not uniform. (3) During the sunset period each station goes through a distinct and individual cycle of change, which is repeated daily. (4) Towards the end of October all observed stations showed simultaneous and large departures from their summer values. This is the beginning of a period of marked day-to-day instability, which persists until the following May, by which time all stations have settled down to their normal summer values. (5) Careful plotting of a day time intensity distance graph gave an undulating curve, showing, under certain conditions, practical extinction at a definite distance. (6) In addition to the slow periodic changes, there appear to be more rapid fluctuations superimposed. During the summer months, they are comparatively small, but assume big intensities during the winter. There is not yet evidence to decide whether these changes are due to fluctuations of layer height too small and rapid to be definitely detected by present methods, or whether they are due to some totally separate cause.

A Motor Firefloat.

A NOTEWORTHY addition to the fire-fighting appliances of the London Fire Brigade has just been made by the delivery, by Merryweather and Sons, of Greenwich, of the new firefloat Beta III., which is illustrated by the line drawing and engravings below.

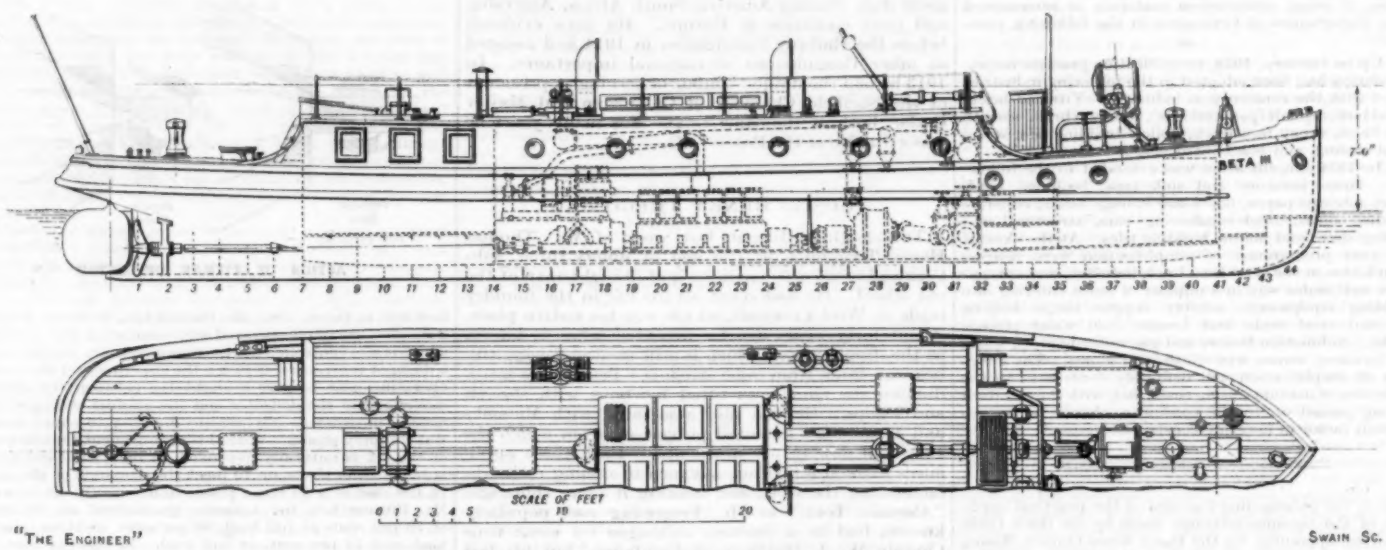
Compared with her older sisters driven by steam, the Beta III. looks small, as she is only 70ft. long by 13ft. 6in. beam, and draws 3ft. 9in. of water. By adopting oil engines it has, however, been possible to instal within this little hull some very powerful pumping machinery, while the boat is naturally much more handy in manœuvring in crowded waters than a larger vessel would be. This handiness was well demonstrated during a recent trip which we made, when the float was brought up, against the tide, through the barges tied up in the Pool with scarcely any slackening of speed. The full speed, by the way, was proved, on the measured mile, to be over 10 knots.



THE MOTOR FIREFLOAT BETA III.

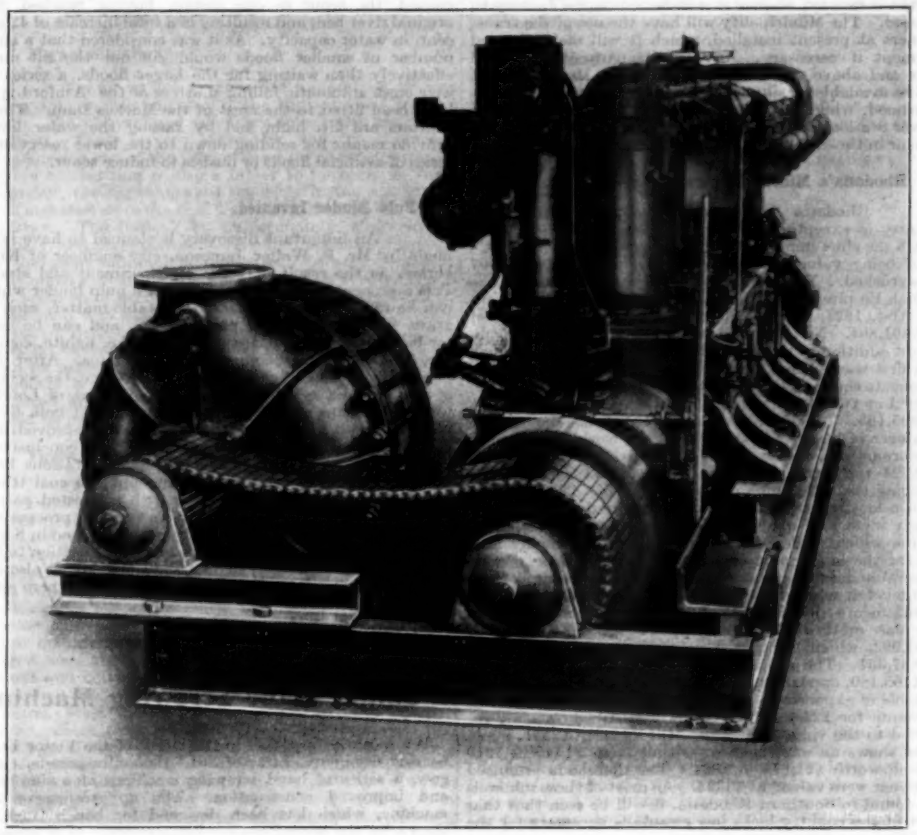
The main machinery comprises two sets of six-cylinder oil engines, each capable of developing 110 brake horse-power when running at 500 revolutions per minute. These engines are started up on petrol, and after a few minutes running are switched over to paraffin. As will be seen from the line drawing, there is a clutch at each end of each engine. Those at the after ends are, of course, used to drive the propellers, and the two parts of the clutch are completely separated when it is open, so that there is no possibility of the propellers being turned accidentally. The forward clutches are used to connect the engines with the fire pumps through chain gearing. This gear can be plainly seen in the engraving of the engine, and increases the speed of the pump up to 1000 revolutions per minute. There are two chains, of the silent tooth type, side by side for each drive. In the boat the chains are covered with guards to prevent oil splashing about. It will be noticed that outboard bearings, of the ball-bearing type, are provided for both shafts.

The pumps are of the makers' standard turbine type, of gun-metal throughout, and each of them is nominally rated to deliver 1000 gallons a minute against a pressure of 90 lb. per square inch. Under test conditions, however, each pump actually delivered 1350 gallons a minute at that pressure and when the delivery was reduced to 1000 gallons the specified pressure was exceeded by about 30 per cent. At a pressure of 50 lb. per square inch the quantity was 2400 gallons a minute for each pump, and the discharge was correspondingly increased at even lower pressures.



ARRANGEMENT OF THE MOTOR FIREFLOAT BETA III.

An elaborate system of piping and valves is arranged immediately below the deck for connecting the pumps with a monitor, and two deck hose-connection boxes. Connections can be made so that either, or both, pumps



ENGINES AND PUMPS OF MOTOR FIREFLOAT BETA III

can serve either the monitor and the deck boxes simultaneously or the monitor alone, or either of the deck boxes separately, or both together. There are sockets for four hoses on each of the boxes, and the monitor is arranged to take nozzles from 1¼in. up to 3¼in. in diameter. Provision is also made on deck for hose connection to the suction branches of the pumps, so that they can be used for salvage purposes if necessary.

The auxiliary machinery includes two combined dynamo and air compressor sets driven by oil engines. The air compressors are, of course, for providing air to start the main engines, while the current from the dynamos, besides being used for general illumination, serves a 20in. Admiralty type searchlight mounted on the fore deck. The fuel capacity of the tanks is sufficient to keep the whole of the machinery running at full load for twenty-four hours. The exhaust from the main engines is taken overboard by pipes running right aft to the counter and the cooling water from the cylinder jackets is led into these pipes, which helps naturally to deaden the noise of the exhaust. There is a cabin aft with a galley large enough to serve a good force of men, and in this cabin there is also a stove to heat water for circulation round piping arranged in the machinery space to prevent the engines getting too cold when not in commission. There are the usual conveniences in the way of lavatory accommodation on board.

At the end of the run to which we have made reference, the boat was tied up alongside the Brigade's pier at Charing Cross, and some extensive pumping trials were carried out under the supervision of Mr. A. R. Dyer, the chief officer. The comparative quietness of the machinery was noteworthy, and the engine-room was quite comfortable from the point of view of both noise and heat.

The Werkspoor Marine Oil Engine.

IN the course of an interesting paper on the development of the Werkspoor type of marine oil engine, which was read by Mr. G. J. Lugt, of Amsterdam, before the Institution of Engineers and Shipbuilders in Scotland, on Tuesday, the 26th ult., some particulars were given of a new type of valve gear which is being fitted to a series of double-acting engines ordered by the Anglo-Saxon Petroleum Company, Ltd., of London. In all twelve sets of machinery are to be constructed by the Werkspoor Company, of Amsterdam, and its British licencees, the North-Eastern Marine Engineering Company, Ltd., and Hawthorn, Leslie and Co., Ltd. The engines in question are of the six-cylinder type, working on the four-stroke cycle double-acting principle. The cylinder diameter is 820 mm. with a stroke of 1500 mm., and each unit has a designed output of about 6000 indicated horse-power when running at a normal speed of 95 revolutions. The engines will be installed in 440ft. oil tankers of a deadweight carrying capacity of about 10,000 tons, with a sea speed of 12½ knots.

The engine design is based on that of the single-cylinder experimental unit which was described in our issues of May 30th and June 6th, 1924. The novel feature is the top valve gear, which was designed by Mr. C. J. Lugt, in collaboration with Mr. C. Zulver, the marine superintendent of the Anglo-Saxon Petroleum Company, Ltd. Few ships perhaps have as little time for overhaul, inspection, or repair as those which are engaged in the oil carrying trade. The average actual working time of the engines of an oil tanker is, we are informed, about 6500 hours per annum, and even when in port repair work is often prohibited owing to the danger which might be caused by

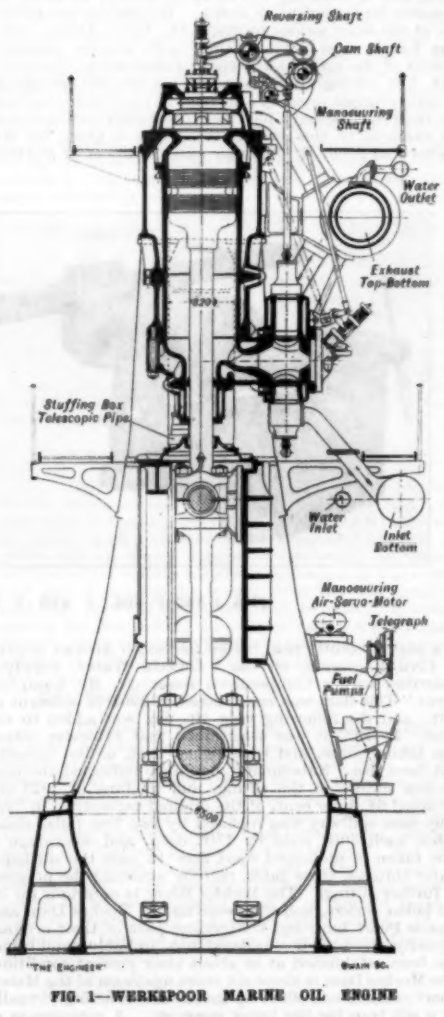


FIG. 1—WERKSPOOR MARINE OIL ENGINE

working with naked lights when oil cargoes of low flash-point are being handled. Taking into account the exceptionally large size of the cylinders, it was held desirable to simplify the design of the cylinder heads as much as possible.

In Fig. 1 we reproduce a vertical section through the engine. It will be seen that the cylinder cover is quite symmetrical in shape, with only a single centre opening to accommodate the necessary valves. This opening of course had to be kept to the smallest diameter possible, and as there was hardly room within it for the inlet, exhaust, fuel and starting valves, it was decided to combine the inlet and exhaust valves. In order to avoid the use of mushroom valves of large diameter, a valve casing, with the fuel valve in the centre, and six small valves arranged symmetrically around it, was adopted. At first sight it would seem that the increased number of small valves would add complication, but experience showed, the designers' claim, that no trouble was to be expected with these small valves if they were well cooled and were run

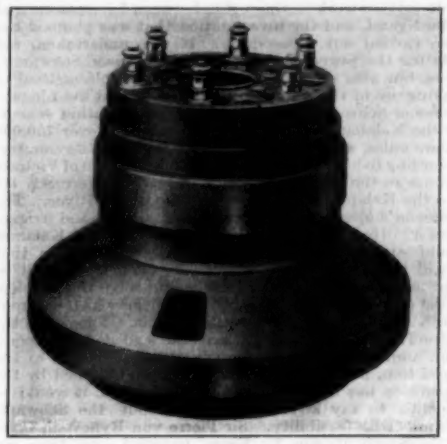


FIG. 2—VALVE CASING, WERKSPOOR ENGINE

at a low speed. The valve casing itself is shown in Fig. 2. It is comparatively light in structure, and its diameter at the seat is only about 60 per cent. of the cylinder bore. A spare valve casing is carried in accordance with the usual practice for ordinary exhaust valves. From each valve a separate passage leads to the cone-shaped seat of the valve casing. In turn the valve casing is surrounded by an oscillating sleeve, in which twelve apertures are made, six of which lead horizontally to the exhaust belt and the other six vertically to the inlet belt—illustrated in Fig. 3. The oscillating sleeve is moved by an excentric which is mounted on the cam shaft, and the motion is such that the exhaust and inlet belts are alternately placed in through communication with the ports in the valve cage. A suitable labyrinth packing is provided between the two belts, and the valve cage is water-cooled. It has not, however, been found necessary to cool the sleeve. The gear presenting a radical departure from standard practice, it was deemed necessary to try out the system

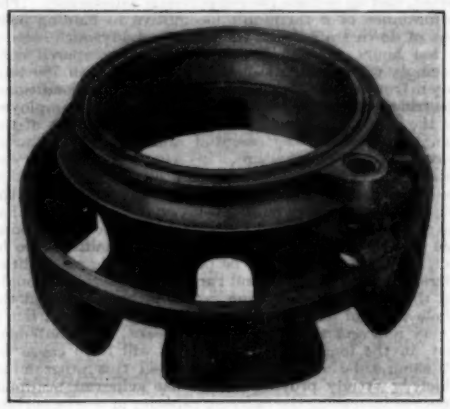


FIG. 3—INLET BELT OF VALVE

before applying it to a large number of cylinders. Accordingly a cylinder head of the new design was fitted to the experimental engine, which was then run for a considerable time with it in operation under conditions which approached, as nearly as possible, those of actual service. It ran, we learn, consecutively for eighty-two days, which is perhaps the longest trial ever made with an experimental engine. During that time the whole of the gear gave, Mr. Lugt informs us, entire satisfaction. Assuming that the engine was propelling a ship the daily distance covered was charted, and the total distance amounted in all to about 26,000 miles. Upon the engine being opened after this long run, it was found that both the sleeve and the valve seating were in excellent condition, and that there was no abnormal wear and tear. When the excentric rod was uncoupled directly after the engine was stopped, the sleeve was easily moved by hand.

The special valve gear we have described will be used for the Anglo-Saxon Petroleum Company's engines, but it must not be confused with the standard Werkspoor valve gear, which will be retained on all standard engines. The first standard double-acting marine oil engine to be completed will be that for Alfred Holt and Co., Ltd., which is now approaching completion at the North-Eastern Marine Engineering Company's works at Wallsend.

In concluding his paper, Mr. Lugt expressed the opinion that there was room for both the four-stroke and two-stroke cycles. The only factors which would determine future development were, he thought, reliabilty, durability,

first cost, cost of upkeep and economy, or, expressed in one word, efficiency. With a view to testing the merits of the double-acting two-cycle principle a large experimental unit of this type was under construction, and would, Mr. Lugt said, be shortly erected in the Amsterdam works of the Werkspoor Company.

South African Engineering Notes.

Irrigation of the Kalahari.

The expedition dispatched by the Union Government into the Kalahari to obtain data with which to test the practicability of Professor Schwartz's scheme returned towards the end of last year. The expedition went out to do certain work in the region between Livingstone and Lake Ngami, and the investigation that was planned has been carried out successfully. It was undertaken, not only for the purpose of examining Professor Schwartz's ideas, but also to consider any other possible method of making use of the waters of the Zambesi and the Lingati. Professor Schwartz has stated that an irrigation scheme for the Kalahari would restore the moisture over 750,000 square miles, and change it from desert to fertile country. According to him, there used to be a lake the size of Victoria Nyanza in the Ngami portion, and that lake formerly led into the Kalahari, and thence to the Orange River. The Professor's idea is to restore the river system and irrigate from it. He believes that if fully irrigated the Kalahari would support three million people. He believes that it will begin as a white settlement scheme, and will be kept as such for all time. This would solve the problem of the poor white and many other problems which confront South Africa to-day. Dr. A. L. Du Toit, Geologist to the Union Irrigation Department, was the leader of the expedition, and, in reply to an inquiry about the result of the expedition, he stated that until the data obtained by the expedition has been arranged and examined, it would be impolitic to say anything further about the Schwartz scheme or its feasibility. Sir Pierre von Ryneveld, Chief of the South African Air Force, reported some time ago that as a result of an aerial survey between the Etosha Pan and the Cunene River, the theory put forward by Professor Schwartz, as to damming up the Cunene, was feasible and practicable. If the report of the expedition is favourable, there is no doubt that the irrigation scheme will be attempted, and if successful it will be of very considerable proportions. Some years ago General Smuts drew up an agreement with the Portuguese Government which would allow the Union to take half the water resulting from the damming of the Cunene, which forms the southern boundary of Angola. The water would fertilise Ovamboland, and the Ovambos, who are about 150,000 in number, would be saved from the danger of extermination by famine.

Natal Railway Electrification.

At the beginning of last December 130 out of the 174 miles of the Natal main line, which is being electrified, were in daily operation, and the drivers and staff generally were becoming accustomed to the new conditions. Leaving out of account a number of derailments and an accident due to lightning, the results, so it is reported, had up to then proved perfectly satisfactory. The performance of a three-unit locomotive in hauling 3280 tons of down traffic over the Glencoe–Ladysmith section in ten hours, making two round trips, compared convincingly with a single round trip, dealing with 780 tons only in from 14 to 15 hours, under the old steam conditions. Electrification in the case of the Natal system was employed for the specific purpose of increasing the capacity of the line. An increase was essential and definitely entailed heavy capital expenditure, in whatever way it was obtained. The capital expenditure on the electrification has been heavy, and has admittedly overstepped the original estimate very considerably, but it is asserted that the excess can be charged to the fact that the undertaking was of a pioneering nature, with special conditions to be met, and regard having to be paid to the big possibilities offered of general urban and rural electrification throughout the length of the system. The latter is an asset the whole value of which will not be quickly apparent, but is a very real and vital one none the less. It is contended that, in the long run, South Africa will have cause for self-congratulation on having adopted this programme, which is already proving that it has achieved the main object of increasing the carrying capacity of this important and congested section. The whole 174 miles will be operating in March next, and that, and the electrification of the Peninsula system, due for completion in some eighteen months, will be important milestones in the progress of the country.

A Novel Power Agreement.

A somewhat unusual arrangement for the supply of power was recently come to between the Durban Town Council and the firm of Sir J. Liege, Hulett and Sons, Ltd., owners of sugar mills and refineries on the North Coast of Natal. Their main refinery is situated at South Coast Junction, near Durban, where it is their intention to double the plant to cope with next season's requirements. This intention naturally entails a considerable increase in their power demand, both of electricity and of steam, for refining purposes, but at the same time the Town Council is faced with the difficult problem of meeting its rapidly increasing demand until the Electricity Supply Commission's new undertaking is in operation at Congella, which is not expected to be until October, 1927. An arrangement has therefore been come to between the Town Council and Messrs. Hulett, under which the former has just placed an order with W. H. Allen, Sons and Co., Ltd., for two 1000-kilovolt-ampère turbines and alternators to be installed at Messrs. Hulett's refinery at South Coast Junction. Messrs. Allen will supply turbines of their own manufacture, directly coupled to three-phase 50-period alternators, made by the General Electric Company, Ltd., Birmingham. One alternator will supply current at 6600 volts, and the other three-phase current at 550 volts, the speed in each case being 3000 revolutions per minute. The steam for driving these sets will be generated in the company's boilers and supplied to the turbine stop valves at a pressure of 180-200 lb. per square inch, and a superheat of 100-150 deg. Fah. The turbines will exhaust at a pressure of 25 lb. per square inch into a receiver supplied by the company, whence it will be led to the factory to be used. The Municipality will have the use of the transformers at present installed, which it will maintain and augment if necessary. Any surplus current generated over and above the amount required by Messrs. Hulett will be available for supply to other consumers in the neighbourhood, while the existing cable from the Alice-street Power Station will supply current when no steam is available or in the event of the turbines breaking down.

Rhodesia's Mineral Riches.

Rhodesia has undoubtedly proved herself a country of exceptionally varied mineral resources. Gold is still the chief item in the actual output returns, the 1924 total being valued at nearly £2,939,562 from 2,082,867 tons crushed. Nearly 5 per cent. of the gold output of the British Empire comes from Rhodesia, which up to December 31st, 1924, had produced gold to the total value of £30,461,804. Next to gold, in value, is a comparatively recent addition to the list, in the shape of asbestos, which was first worked in a small way in 1908. So rapidly has it come to the front that in 1924 the output was 26,141 tons, valued at £603,423, making the total value of the output £3,995,165. Rhodesia is now regarded as the largest producer of high-grade asbestos in the world. Chromite, or chrome ore, claims third place in the list, of which 172,724 tons were raised in 1924, valued at £432,482, bringing the total value up to £3,281,465. The fact that such a low priced mineral can be exported at a profit in yearly increasing quantities is due to the size of the deposits, which render the mining costs exceptionally low. By far the larger part of the world's production of this mineral is derived from this source, and unless prices fall to a level at which it will not pay for transport, it should maintain its position. Coal occupies a comparatively low place on the list, with an output of 652,049 tons, worth £265,992, which brings the value of the total raised to £2,837,361. The copper production of 2827 tons, valued at £165,480, appears small, and the output is undoubtedly capable of expansion, and, of course, will expand. Silver accounts for £22,488 from 166,479 oz., while arsenic reported to the value of £20,780; tin for only £2331, while mica shows an expansion in output from £1345 in 1919 to one worth £21,674 in 1924. The diamonds produced last year were valued at £3322. As most of these minerals are found in Southern Rhodesia, it will be seen that that part of the country lacks few essentails necessary for the building up of important industries.

Reservoirs Troubled by Silt.

With few exceptions all South African rivers carry a heavy burden of silt and sand during flood, much of which is deposited in such reservoirs as they serve. In some districts this silting is assuming considerable proportions, and is naturally the cause of anxiety to those responsible for the irrigation works. It certainly constitutes one of the most serious problems the South African engineer has to face when dealing with storage schemes. Certain of the earlier waterworks undertakings, have, it is said, lost through this cause a considerable percentage of their original capacity; in fact, in more than one case the reservoir capacity has been practically extinguished. An example of this progressive silting is given by Mr. Walter Campbell, the borough water engineer of Durban, in a paper recently read before the South African Society of Civil Engineers, on the "Durban Water Supply." Referring to the Camperdown Reservoir, Mr. Campbell says: "This dam was constructed in 1902 to a height of 41ft., and the following year 4ft. 6in. was added to the crest. In 1923 it was ascertained that extensive silting was taking place, and that 38 per cent. of the capacity had been lost. Subsequent soundings indicated the continuous nature of the silting, and in June of 1925 silt occupied 68.5 per cent. of the original capacity. In 1923 a by-pass spillway was replaced by two free roller sluice gates, each 30ft. wide by 11ft. deep, and advantage is now taken of prolonged flood flow to pass the silt-laden water through these gates, thereby arresting the progress of further silting. The Modder River is notorious for its silt-laden waters, and the reservoirs at Mockes Dam and Mazels Poort have lost the greater part of their original capacity, though it is considered that, probably, equilibrium has been established at or about their present condition. The Mockes Dam is about six miles upstream of the Mazels Poort scheme, and silted up much earlier, acting virtually as a silt trap for the lower reservoir. A commission of engineers recommended the substitution of large gate barrages for the existing weirs. A first section of the work has now been completed by cutting the Mazel Poort Dam through the centre, and erecting a free roller Ashford sluice gate, 40ft. wide by 21ft. 6in. high, in the opening, the flanking piers with grooves to take the free roller path of the gate being built on the downstream face of the dam and bonded into it. The gate has recently been brought into use, and a great measure of silt removal has already ensued, the scour in one section having reached the original river bed, and resulting in a total increase of 42 per cent. in water capacity. As it was considered that a large number of smaller floods would cut out the silt more effectively than waiting for the larger floods, a series of weir crest automatic falling shutters of the Ashford type have been fitted to the crest of the Mockes Dam. These shutters are 5ft. high, and by raising the water level, provide means for sending down to the lower reservoir a series of artificial floods or flushes to induce scour.

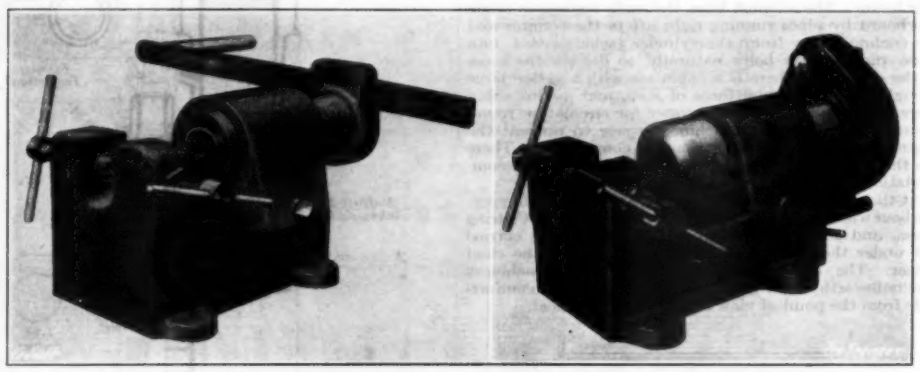
Pulp Binder Invented.

An important discovery is claimed to have been made by Mr. F. Walter Jameson, city engineer of Kimberley, as the result of years of experiment and study. It is a process for the manufacture of a pulp binder which can be made from almost any vegetable matter, such as grass, weeds, sugar beet residue, &c., and can be used for binding into briquettes fine coal, coke, lignite, copper ore, salt and other commercial aggregates. After the pioneer work had advanced to a certain stage, the services of two eminent consulting chemical engineers of London were enlisted to carry out research work and bulk tests, with the result that the process was greatly improved, and the commercial value is said to have been conclusively demonstrated. Recent commercial demonstrations have aroused considerable interest throughout the coal trade, with the result that negotiations with interested parties in several countries for the right to use the process are proceeding. Hitherto pitch has been mainly used in South Africa as a binder, but it is claimed that, in addition to the pulp binder being better, cleaner and smokeless, it also has the advantage in cost, particularly in countries where pitch has to be imported.

A Simple Hand Screwing Machine.

WE recently inspected in the works of the Victor Engineering Company, Ltd., of 261, Alexandra-parade, Glasgow, a series of hand screwing machines of a simplified and improved construction. The appearance of the machine, which has been designed for bench work, is shown by the accompanying illustrations. It is strongly built in steel, and should be of service in any works where repetition screwing is required. It has, we understand, proved particularly useful for screwing U-shaped pieces, such as spring stirrups, buckles and pipe hangers, for such parts may be screwed right up to the bend even although there is only a distance of 1¼in. between the two parallel limbs. Engraving Fig. 1 shows the No. 1 size of machine, which is built for work up to ¾in. in diameter, and is usually supplied with four dies up to that size. If desired, ¾in. and 1in. dies can also be fitted, but they entail harder work for the operator, although the machine is designed to be quite strong enough to take the extra stress imposed. The normal time required for screwing a ¾in. bolt up to a length of 2in. is given by the makers as three minutes.

An interesting feature of the machine is the method which is employed to put pressure on the dies to start them.



FIGS. 1 AND 2—NOS. 1 AND 2 VICTOR HAND SCREWING MACHINES

Part of the spindle is furnished with a series of circular grooves of involute shape, which engage with a transversely arranged pinion and form a continuous rack. The pinion shaft is squared and pressure is applied by a small hand lever. A two-screw vice with right-handed screws is used, and it is claimed that by this means a simple, direct and strong grip, superior to that of a self-centering chuck, is obtained. In order to assure the operation of centering the work, the vice jaws are marked at intervals so that the distance they stand out from the vice cheek can be quickly gauged by the eye.

Illustration Fig. 2 serves to show some of the special features of the No. 2 size of machine, which is built to screw work up to 1¼in. in diameter, with either a Whitworth or a gas thread. It differs from the machine which we have already described in that the dies are held in a special cap, which is fitted on to the nose of the spindle by a bayonet joint. Such an arrangement enables the dies to be quickly changed, and the design of the cap is such that the metal cuttings are effectively removed from the dies and clogging prevented. The No. 2 machine is geared with a four-to-one ratio, and is so designed that the gear can be thrown out of action by a catch and a quick-return given. Four dies represent the general equipment supplied with this machine.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Market Situation.

THERE is but a moderate amount of business being done in iron and steel in the Midlands and Staffordshire. Both buyers and sellers are acting with the utmost caution. Trade is very spasmodic, and the absence of steadiness is one of the prime causes for anxiety, while the severe competition is also a factor to be borne in mind. However, the slight upward tendency in the demand for iron and steel since the New Year set in shows a disposition to stay. The outlook is, unfortunately, shadowed by anxiety, and manufacturers can only hope that difficulties in the great national industries will be smoothed over. It is urged that if the crisis in the coalfields is to be made the occasion of active contention, ground which has been laboriously won will inevitably be lost again, and the whole fabric of British industry must be jeopardised. Everybody hopes that the Commission will produce an acceptable plan for carrying on, but the belligerent spirit of the protagonists is not encouraging. However, could this be achieved and confidence restored, it is considered there would be good hope of a gradual trade recovery.

Finished Iron.

The Staffordshire ironworks are slightly busier, but orders are for small tonnages only. Marked bars are in fair demand at £14. The competition from Lancashire houses having fallen off a little, producers of Crown bars are attempting to get slightly more than £11 10s. for their products. Many of them this week quote £11 12s. 6d. and others £11 15s., but it does not appear that business is being put through at these figures. There has been a further contraction of the common bar trade due to the more determined competition from Belgium. Staffordshire houses quote £10 10s., a price which does not appeal to nut and bolt makers, who can now get ample supplies from the Continent. This week, for the first time for some months, price lists are being issued by the Charleroi works, where the prolonged strike has now terminated. Continental exporters have been talking for some time of higher prices, but the latest lists show no advance, and for No. 3 nut and bolt making iron, the quotation of £6 15s. represents a fall of about 5s. below recent figures. Some of the iron strip makers are better occupied than recently, thanks to an improvement in the Staffordshire tube trade; £12 10s. per ton is paid for this material.

Pig Iron.

Pig iron continues the strongest department of the Midland iron and steel market, nearly all the blast-furnaces having booked orders well into March. Consumptive demand has been pretty well covered for the time being, and little new business is being transacted. Buyers demur at the upward tendency of quotations. Smelters are not disposed to carry unaided the extra burden of dearer coke, and they prefer a policy of restricting output if there is no other way of securing compliance with their increased demands. Midland smelters firmly adhere to their recent increased prices. Derbyshire makers want £3 7s. 6d. at furnaces for No. 3 foundry and Northamptonshire smelters ask £3 4s. to £3 5s. One of the effects of the small consumption of forge pig iron is that this quality of iron shows less strength than other brands, and can be bought slightly more favourably in comparison. The Staffordshire ironmaster cannot afford to pay more for his raw material, and is resisting to the utmost the effort to raise prices. Any blast-furnace willing to accept forward contracts would be sure to find ample business, but smelters prefer to await developments.

Iron Trade Records.

The records of the Midland iron trade for November and December last not only indicate that the downward course of values continues with painful monotony, but also that output is also declining. The reduction of 10s. in marked bars midway through the period emphasised the gradual depreciation which was already in progress. Output was, of course, affected by the Christmas holidays, but it was not only down 3000 tons, as compared with the turnover of the selected firms in the preceding two months; it showed a still greater drop on the total for the corresponding months of 1924. During the two months values receded by 6s. per ton. Angles and tees were in better demand, but there was a heavy relapse in bars, as well as in hoops, strip and miscellaneous material. The result of the ascertainment is, as stated in my letter last week, to lower wages 2½ per cent.

Steel.

Midland steel mills are making fairly good time, although there is still a large surplus of plant insufficiently supplied. This results in keen competition for all available business, and easy prices are quoted where good tonnages offer an attraction. The constructional demand is well maintained, new business constantly coming out, which, however, for the most part is at present subject to tender by constructional engineers and others. The modest gains which producers of finished steel have secured since the opening of the year are maintained. For sections £7 2s. 6d. is now the accepted minimum. Though a few good tonnages of constructional plates have been recently accepted at £7 15s., the prevailing market rate is based on £7 17s. 6d. Small steel bars rolled from continental billets can still be got at £7 17s. 6d. For Crown quality rolled from English billets, £8 5s. is received. Boiler plates are in little demand at £11 upwards. Staffordshire hoops command £10 10s. at works. There is not much trade passing in semis. Billet makers generally want £6 5s., but some business is still done at £6 2s. 6d. Continental offerings are small, and values continue to harden. Belgian billets can be had at £5 11s. to £5 12s. delivered Birmingham. Readjustments effected in the price of wire rods have brought quotations to £9 15s. to £10 for rods rolled from English billets, and £8 10s. to £8 15s. for those rolled from imported billets. Continental rods are about £7 3s. delivered in this district. Germany is increasingly successful in selling cold rolled steel to this district, largely for motor and motor cycle and various engineering requirements. The price quoted is about £4 per ton below the Midland figure.

Galvanised Sheets.

The galvanised sheet mills have a fair margin of orders to work off yet, but new business has been coming forward so irregularly that prices continue to decline. For 24 gauge corrugateds the ruling figure is now round about £16 5s., a figure 2s. 6d. below that quoted a week ago.

Scrap.

Scrap has a very firm tendency. Good piling wrought iron scrap is quoted at £3 17s. 6d. to £4, delivered in the district. Ordinary samples are priced 5s. less. South Wales consumers of steel scrap are asked to pay fully £3 7s. 6d. delivered.

Rolling Stock Business.

The additional contracts negotiated by the rolling stock makers are expected to be augmented in the near future by substantial orders for wagons from the home railways. Tenders are now under consideration. Works are briskly engaged. There has been full employment in the carriage department for some time past, and the slackness which overtook some of the wagon shops in the closing months of last year has changed for the better. The export demand is contributing materially to the improvement. An important railway coach order has been secured by local firms. The order, for 100 passenger brake coaches, for the main line services of the London, Midland and Scottish Railway has been divided between the Birmingham Railway Carriage and Wagon Company, Smethwick, and the Metropolitan Carriage, Wagon and Finance Company, Saltley.

Birmingham Brass Trade.

Many of the Birmingham brass foundries are working at full pressure, but the rolling mills are not as busy as they were. It is expected that substantial orders for tubes, light cone joints and screw-down fittings for domestic water services will be placed in Birmingham in connection with the schemes for erecting steel houses in Scotland. A few orders have been given out already, and as plans develop the demand is likely to be on a scale sufficient appreciably to help employment. Improved orders for brass foundry work are also coming in from some of the foreign markets.

Black Country Mining Problems.

That the closure of the Old Hill mining area would result if the policy of district wages settlements is adopted, in connection with a solution of the present crisis in the coal industry, is the view expressed by Mr. Samuel Edwards, the miners' agent for the district. The Old Hill area was formerly looked upon as one of the best coalfields in the country, but it has deteriorated, and is in a very low grade so far as wages are concerned. The only salvation for those engaged in and about the mines in an area of that kind, says Mr. Edwards, is to remain part and parcel of the national movement. Unless they had the support of the national body, small coalfields, such as Old Hill, would, he believed, be crushed out of existence by the large developing areas.

Pit to Reopen.

The Nook Pit at Cheslyn Hay, which was formerly worked by the Great Wyrley Colliery Company, Ltd., is, I understand, to be reopened in the near future. Preliminary arrangements are being pushed forward, and it is most probable that the new proprietors will aim at mining the deep seams of coal in the locality that were at one time worked from the Great Wyrley Pit, which is now closed down. The shallow workings of the Nook Pit are among the oldest in the Cannock Chase coalfields, having been in existence for a century or more.

Electrical Engineering.

Midland electrical engineers are well employed at the moment, and the outlook continues rosy. One important concern, which has established itself in Coventry in recent years and now finds employment for over 3000 workpeople, is busily engaged in producing the electrical equipment for various telephone exchanges in this country and abroad, among the former being the new automatic exchange for Coventry, which will be ready for opening during the first half of the current year. A good deal of work is likely to come to them when the plans for a unified scheme of current supply is put in hand.

Edge Tool Trade.

Business in the edge tool trade in the Midlands is irregular, and while some establishments are fully employed, others are only working short time. It is to some extent accounted for by the fact that while the Eastern market has enjoyed a mild boon for some months, the South American market has been exceedingly quiet. The former market remains brisk, with every indication that it will continue so for some time to come. The South American market, however, has not yet shown any real improvement. The situation, however, is this week reported to be more hopeful, and it is thought there are distinct prospects of an early improvement. A fair amount of business is coming through from Australasia and South Africa.

Unemployment.

The improvement in the labour market in the Midlands area is continued, the past fortnight having seen a big decrease, over 10,000, in the number of unemployed and partially employed workers. In the current return the total of wholly unemployed is 129,754, as compared with 134,448 in the previous return, and 139,891 a fortnight ago. At the same time, there is an improvement in the number temporarily unemployed, the present total being 41,148, as compared with 44,577 in the last return, a decrease of 5944 in a fortnight.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

American Control of Pig Iron.

SPEAKING at the annual dinner of the Lancashire Branch of the Institute of British Foundrymen, which was held on Saturday last in Manchester, Mr. Oliver Stubbs referred to the statement made by Sir Allan Smith, that a deliberate attempt was being made by Americans to control the manufacture of pig iron in Europe. Mr. Stubbs said that it was very disturbing to the foundry industry in this country to hear that the Americans had invested so much in German and French pig iron businesses that they hoped to be able to rig the market and compel buyers in this country to purchase pig iron at the price fixed by Americans.

The Cotton Trade.

The annual report of the Federation of Master Cotton Spinners' Associations just issued, referring to the prevalent trade depression, states that the causes of bad trade are the internal turmoil in China—which may be remedied by the opening of the Shanghai auctions—the failure of the Indian market, and Japanese competition. The report states that as long as Japan was able to continue to enjoy the unfair advantage of producing on the basis of a twenty-hour day working week it was difficult to see how Lancashire could possibly hope to restore her supremacy in Far Eastern markets. The question of working hours was one which should receive early consideration at the hands of an international tribunal. With a "bumper" cotton crop and the price down to round about tenpence per pound better trade should be experienced. It was difficult to see how costs of production could be materially reduced, and it was hoped that if the occasion arose having regard to the unfair advantage enjoyed by labour in competing countries, the textile operatives of Lancashire would lend their co-operation and assistance to employers in a closer approximation of international working hours in textile trades.

Manchester as a Cotton Port.

The value of Manchester as a cotton port formed the subject of a lecture given by Mr. Frank Nasmith at a meeting of the British Association of Managers of Textile Works held in Manchester on Saturday last. The author said that although it was only opened in 1894, the Port of Manchester was the fourth in the United Kingdom regarding the value of its imports and exports. Manchester was now receiving more than 50 per cent. of the total imports from Egypt into this country. The nature of the accommodation for cotton on the quays or in storage warehouses was best realised by the fact that the authorities at New Orleans had determined to erect their new port extensions on the pattern of Manchester. With regard to the new road from Liverpool to Manchester, Mr. Nasmith said that it would be a serious competitor to all forms of haulage.

Manchester Chamber of Commerce.

The annual meeting of the Manchester Chamber of Commerce was held on Monday last, and in moving the adoption of the annual report, the president, Dr. Rée, reviewed the trade of the country during the last twelve months. Speaking of the chemical industry, with which he is most intimately connected, Dr. Rée said that, in the future of the nation, chemistry would play a part of an importance which very few realised to-day. He would go so far as to say that our future industrial and commercial existence depended to a predominant extent on the chemist and his work. The greatest encouragement should therefore be given to those who had the ingenuity to turn chemical knowledge to practical use in the service of humanity. There was need, too, for further improvement in the law relating to patents. At a meeting of the new board of directors, Sir Percy Woodhouse was elected president of the Chamber, to succeed to Dr. Rée.

Liverpool Engineering Society.

The annual dinner of the Liverpool Engineering Society was held on Thursday, the 4th inst., at the Midland Adelphi Hotel, Liverpool, when there was a very large attendance of members and friends. The president, Mr. T. R. Wilton, M. Inst. C.E., was in the chair. Sir Henry Fowler, K.B.E., M. Inst. C.E., acting president of the Institution of Mechanical Engineers, proposed the toast, "The Imperial Forces," which was responded to by Lieut.-General Sir Richard H. K. Butler, K.C.B. The toast, "The Engineering Profession," was entrusted to Mr. Stuart Deacon, stipendiary magistrate of Liverpool, who said it was in the power of the engineering profession to extract from Nature's casket the hidden secrets, and to translate them into means which would prove beneficial to the human race. Engineers were missioners of peace in the world, and had a great opportunity to translate the hopes and goals of the League of Nations into a practical reality. In response to this toast Mr. Wilton mentioned that the Liverpool Engineering Society had now about 900 members. He claimed that it was one of the great provincial societies and comprised engineers of all denominations, who met together and discussed subjects of mutual interest. The toast of the "City of Liverpool" was proposed by Major-General H. de Pree, who said that he knew no place in the world at the present time which had two such great works in progress as the Mersey Tunnel and the Gladstone Dock extension. The reply to this toast was made by the Lord Mayor of Liverpool, Councillor F. C. Bowring, who claimed that Liverpool was one of the first cities to take advantage of all improvements in the engineering world. The toast,

"Our Guests," was appropriately proposed by Lieut.-Colonel J. R. Davidson, M. Inst. C.E., and replied to by Mr. T. Rome, who took a rather pessimistic view of the state of trade, remarking that about this time last year they were all convinced that trade had turned the corner, and that they were on the eve of better times, but the promise had not been fulfilled. He said it was true that the Port of Liverpool was maintaining its position relative to other ports in the Kingdom, but hoped they would not forget the lesson of last year. He said that all would have to work harder and try to make more trade.

BARROW-IN-FURNESS.

Hematite.

There is no alteration in the hematite pig iron trade, generally speaking, but a slight hesitancy is noticeable which may just be momentary or may be due to the uncertainty of the future in regard to the coal dispute. Makers are practically clearing what iron they have available, but the steel departments in Workington and Barrow are taking their share, and not a small one, of the iron which is smelted. Orders are held for deliveries up to April, but there are not many orders about for deliveries beyond that date at the present time. A big share of the tonnage is going to the Midlands and Scotland, while Wales is a customer to a smaller extent. The business with the Continent at present is not worth talking about. American business keeps occurring, but it is spasmodic. There have been recent shipments from Barrow to Baltimore and other American ports.

Iron Ore.

The iron ore trade is in about the same condition as it was last week, and there will not be any further developments until there are more furnaces in blast in the district, which, according to the present outlook, is not likely in the near future. Foreign ores are in moderate but steady demand, and there are arrivals at intervals at West Coast ports.

Steel.

The steel trade has not any surprises, and orders are held by both Workington and Barrow which will keep the former going in the rail mills three out of four weeks per month. The Barrow rail mills are kept going all the time, but fresh orders are needed to avoid a stoppage when present contracts have been completed in about two months or so. The small section and hoop mills are fairly well off for orders. Foundries are moderately employed.

SHEFFIELD.

(From our own Correspondent.)

Quietness in the Steel Trade.

THE month of February has not opened well for the steel trade on either the light or heavy side. In view of the signs of improvement in shipbuilding and other steel-consuming industries, it is somewhat surprising that the little spurt which Sheffield showed last month should have fallen off so soon, and it is to be hoped that it is due merely to a temporary swing of the pendulum. In some quarters it is attributed to the tightness of money, and a weaker financial position in the country generally. There is no improvement to report in the crude steel section, but, in view of the probability of continental prices rising owing to economic difficulties, makers still regard the outlook with optimism. A feature of the export trade in finished steel and tools is that, while a fair number of orders and inquiries are afoot, the prices offered are extremely low. A considerable amount of work has been taken at rates which can yield no profit, and will only achieve the object of keeping workmen employed and plants running. In other cases, firms report that at the prices obtainable the orders are not worth troubling about.

Cutlery and Plate.

The cutlery and plate trades also have started the year badly. The cutlery side is very flat, especially in the branches devoted to medium and cheap qualities of pen and pocket knives, scissors and ordinary razors. A fair amount of trade in stainless knives is being done by the small makers who are able to cut prices very fine. Many of the bigger firms report quietness on both home and export account, the level of business being below that of a year ago. The next week or two should give definite indications as to the prospects of trade through the ordinary distributing channels, as travelling representatives are just starting on their rounds. The reports so far received from shopkeepers are unsatisfactory, and show that business over the counter continues to decline. Apart from hotel and restaurant supplies, the demand for hollowware is on a smaller scale than for some years past. The sale of spoons and forks keeps up to a fair level, but is considerably below that of last year. Government contracts for supplies of tools, files and cutlery to the Army, Navy and other Departments are now under consideration. Considerable quantities are required, although they are not up to the pre-war standard. They include 10,500 hollow-ground razors of the ordinary pattern—in respect of which alternative tenders for hand-forged and machine-forged blades are asked for—12,000 scissors, 40,000 hair combs, 8000 spike knives, 3500 carving knives, and 2500 carving forks.

Stainless Steel Hollowware.

Some discussion has been going on recently with regard to the attractiveness or otherwise of table hollowware made from stainless steel. The material has many advantages which are fully admitted, among them being strength and durability, the fact that no cleaning is required to maintain the original brightness, and the saving in domestic labour which is thus effected. Criticism has, however, been levelled at its colour, which, although brilliant, is darker than that of silver. Some members of the trade are of opinion that this will act as a deterrent to the adoption of the material by those who, having been accustomed to the presence of silver on their tables, will hesitate about buying articles of a different shade. The makers of stainless steel, however, are inclined to consider that this attitude will gradually wear away in face of the numerous merits of the material.

Sheffield and New Cruisers.

The armament and other heavy departments of Sheffield trade are looking for an accession of work as the result of the placing of orders for two British cruisers under the 1925 programme. It is expected that the contract for one of the vessels will be placed on the Tyne and the other on the Clyde. Wherever the yards to which they are allotted may be, however, the contracts for material, engines, guns and accessories, will be so spread out that every shipbuilding and munition district should obtain some of the work. It is understood that the cruisers will be of about 10,000 tons each, and will cost from £1,500,000 to £2,000,000 each. The anticipations of the munition departments are not confined to these vessels, but also contemplate the placing of three more cruisers in 1926–7, in addition to which it is expected that a large pontoon dock for the Singapore naval base will be ordered shortly.

Successful Coal Sinking.

The Staveley Coal and Iron Company, Ltd., which is sinking a new shaft at its Markham No. 1 Colliery, reached coal last Saturday at a depth of 691 yards. It will now proceed to prove the seam, and if it is found to be satisfactory, all haste will be made with the sinking of the additional shaft.

Local Railway Development.

In order to expedite traffic on its busy main line between Sheffield and Doncaster, the London and North-Eastern Railway Company has decided to provide ten additional double-ended sidings and two reception lines. The work will be carried out chiefly in the Rotherham district, in order to provide adequate accommodation for expected industrial developments. The sidings at Rotherham-road Station will be extended, so as to accommodate 600 wagons necessary for coping with the increasing output at the Parkgate Iron and Steel Works and at Earl Fitzwilliam's Parkgate coke ovens. Additional sidings are also to be constructed at Templeborough, near the works of Steel, Peech and Tozer.

The Late Mr. T. W. Ward.

Not only Sheffield, but the country generally, lost an outstanding figure in the iron, steel and allied industries by the death last week of Mr. T. W. Ward, J.P., founder of the well-known firm of Thos. W. Ward, Ltd. Mr. Ward's career was one of the recent romances of industry, for, beginning in a small way, at the age of about twenty-four, as a coke and iron dealer, he afterwards developed a business of dealing in scrap iron and steel, ship dismantling, buying and selling of contractors' plant, railway stock and machinery, which grew to an enormous size. In the course of its transactions the firm has made some very large purchases of obsolete warships and other vessels. It now comprises no fewer than thirty-two undertakings, owning extensive properties in various parts of this country and Ireland, and fourteen of the works have large quay accommodation for ocean-going vessels. Mr. Ward was Master Cutler of Sheffield in 1913, and President of the Chamber of Commerce in 1912 and 1913. He presented the Chamber with a handsome gold badge, which is worn by the President for the time being. He was seventy-two years old.

Big Humber Scheme.

With the object of allowing larger ships to reach Goole, a scheme has been afoot for some little time for constructing training walls at the confluence of the rivers Ouse and Trent with the Humber. It was stated at Hull last week that this will have to be followed by a further scheme, which will bring the total cost up to £500,000.

NORTH OF ENGLAND.

(From our own Correspondent.)

Foreign Competitors Beaten.

THE outstanding feature in commercial circles in the North of England this week has been the placing of a number of orders for new vessels, as a result of which shipbuilding prospects have brightened perceptibly. Two are for 10,600-ton motor vessels for the Grace Line, of New York, secured by the Furness Shipbuilding Company, of Haverton Hill, near Middlesbrough. In addition, the firm has received an order for a large grain-carrying vessel for the Canadian Lakes. These orders have been secured in face of keen competition from Dutch and German builders who have specialised in motor ship construction since the war. The two vessels for the Grace Line will be 485ft. in length, 54ft. in beam, and 36ft. 6in. in depth. They will be fitted with twin sets of Sulzer-Diesel two-cycle engines of the latest type, coupled direct to twin screws, and will have a maximum cruising speed of 17 knots. Whilst the main engines will be built in Switzerland, virtually the whole of the assembling and installation work will be carried out at the Haverton Hill yard by the shipbuilding company's own engineering staff. Steam has been virtually eliminated from the specifications, the whole of the auxiliary deck machinery being operated electrically with power generated by four Diesel-dynamo installations per ship. Luxurious accommodation will be provided for 200 first-class passengers. Whilst the vessels are primarily designed to meet the demand for ultra-modern ship accommodation on the New York–South American run, 20,000 cubic feet of refrigerator space will be provided for cargoes of a special nature. It is understood that the keel of the first ship will be laid within six weeks, and by August there will be employment in the Haverton Hill yard for 2500 men. The contract is expected to occupy about eighteen months. The Commonwealth and Dominion Line has placed orders for two twin-screw motor vessels with Swan, Hunter and Wigham Richardson and Co., one to be engined with Doxford oil engines, constructed by William Doxford and Sons, Sunderland, and the other with Sulzer-Diesel engines, constructed by the Wallsend Slipway and Engineering Company. The vessels will be of the same size, namely, 475ft. by 63ft., and of about 8000 tons gross, with a net deadweight tonnage of 11,600 tons. Their speed will be about 14 knots fully loaded. They are to be constructed for the regular service between England and Australia and New Zealand, and cargo space in each vessel will be insulated for the carriage of frozen meat, dairy produce and fruit. Accommodation will also be provided for a small number of saloon passengers. Orders for two large cargo steamers have also been secured by the Smith Dock Company, to be built at its shipyard on the Tees.

Cleveland Iron Trade.

Conditions in the Cleveland pig iron trade show little change from last week. The strength of the market is well maintained, and a diminished volume of business is not due to any lack of demand, but rather to the lack of supply, virtually the whole of the output for the current month having already been sold. The extra blast-furnace lit last week is merely to make provision for the fulfilment of the big American order for special foundry iron, and it is understood that another blast-furnace starting at the South Bank works of Bolckow, Vaughan and Co., Ltd., is to produce ferro-manganese, so that the current output of ordinary foundry and hematite iron is in no way increased. However, some step in that direction would create no surprise, as the fuel market is again easier and disposal of any additional output of iron is now fairly well assured. Prices are unchanged, and that, too, is all to the good, as a stabilisation of prices gives buyers more confidence to operate. Current home quotations are:—No. 1 Cleveland foundry iron, 72s. 6d.; No. 3 G.M.B., 70s.; No. 4 foundry, 69s.; No. 4 forge, 68s. 6d.; and mottled and white iron, 68s. To all these prices 6d. per ton more is added for export orders.

Hematite Pig Iron.

Active conditions continue in the East Coast hematite pig iron trade. The market seems stronger than ever, and 78s. per ton is now a minimum figure for East Coast mixed numbers, with No. 1 at 78s. 6d. per ton.

Ironmaking Materials.

Deliveries of foreign ore continue on a very heavy scale, the Tees imports so far this month amounting to over 75,000 tons. New business is reported on the basis of 21s. 6d. per ton c.i.f. Tees for best Rubio ore. Coke is easier, and good Durham furnace qualities can be bought at 21s. per ton delivered at the works.

Manufactured Iron and Steel.

Better accounts are given of the manufactured iron and steel trade. The placing of several new orders for ships and the circulation of further inquiries for new tonnage create a more optimistic feeling in the steel trade. Less foreign material is being imported, with the result that there is an increased consumption of British sheets, bars, billets, &c., and the rail mills and the galvanised sheet works are very busy. Other branches, however, report only a quiet trade. Prices are unaltered.

The Coal Trade.

The position in the Northern coal trade is not so satisfactory as it was a week ago. There is now an increasing pressure of sellers, while buyers are inclined to hold off the market. Consequently, the outlook is somewhat irregular. Fitters of all descriptions of Northumberland and Durham coals are well sold ahead, but contractors are finding some difficulty in clearing their export commitments owing to foreign consumers holding off, and they have to try to clear on the home market; but so many are in this position that pressure for early clearance of all qualities is reacting and causing a decline in values. The recent higher prices asked for coals, and the very substantial rise in freight rates mean a considerable difference to foreign buyers, amounting to many shillings per ton, which accounts for the check in operations. For this month's clearances practically all qualities can now be discounted. Best Northumberland steams, while quoted direct at 17s., can be obtained through second hands at 16s. 6d., and second steams at 15s. 6d. Durham coal business moves along quieter lines, and the position is not nearly so strong as it was last week. Secondary and similar qualities of the cheaper brands are easier in price, but all descriptions are steadily maintained. Coking coals are in reduced demand, and quotations are down to 15s. 6d. for the inferior kinds, and 16s. 3d. to 16s. 6d. for good unscreened grades. Gas coals continue to be the steadiest section, with heavily stemmed early positions, and prices are steady all round. There is no expansion in the demand for coke, but business is slow. The feeling, however, is steady for gas makes, on account of fairly full order books.

SCOTLAND.

(From our own Correspondent.)

Markets Remain Quiet.

THE past week has been almost devoid of fresh interest so far as the steel, iron, and coal industries are concerned. Reports of shipbuilding and locomotive contracts have created a better feeling in local industrial circles, but a considerable period of time must necessarily elapse before the influence of these contracts is felt. Steel and ironmakers are hopeful that the local industries will benefit considerably, but the price of the home article may prove a barrier to business. Meanwhile, though there may be a better feeling apparent, business in the various markets continues on very quiet lines.

Pig Iron.

There is no sign of any brightening in the pig iron outlook. The export demand has perhaps been a shade brisker, but the trade is most disappointing. Home buying for the most part is slow, and confined to small lots. Prices are nominally unchanged, but are subject to considerable fluctuation when any business is in prospect.

Steel.

The volume of new business in steel is rather disappointing, and with present commitments being rapidly worked off the outlook is unsatisfactory. Shipbuilders and engineers may benefit from recent contracts, but it would take more than the steel material represented in these contracts to create a lasting improvement at the steel works. Neither plates nor sections are particularly busy, and prices are unchanged.

Steel Sheets.

The turnover in light steel sheets provides a welcome relief in an otherwise dull market. The export demand for black and galvanised sheets is particularly well maintained, and producers have heavy order books. Heavy sheets show a little more movement, and it is hoped that the improvement will continue. Prices are very firm.

Iron.

The bar iron works have been a shade busier during the past few days. This has not affected the iron market, however, as the improvement has been almost entirely confined to the steel department. Iron makers still encounter keen competition, and business is mostly of small dimensions. For re-rolled steel extremely keen prices have to be quoted in order to obtain even a small proportion of the business on offer. The capacity of the works is in no wise tested, and employment is irregular.

Coal.

Many of the collieries have still a considerable amount of business on their books, especially for export, and therein the position of the trade is satisfactory. Lanarkshire splints and best Fifeshire steams are very well booked ahead, chiefly for shipment to the Mediterranean and South America. Lanarkshire ells and steams are only moderately placed, while second quality Fifeshire and Lothians steams are not particularly busy. Some descriptions of round fuel are being freely offered through second hands, owing to a drop in home demands, and prices of these are easing. Washed nuts are not quite so busy as formerly, and prices are easing with the exception of treble nuts in Fifeshire, which fully maintain their recent firmness. Aggregate shipments amounted to 264,898 tons, against 272,760 tons in the preceding week and 239,219 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

THE improvement in the steam coal section has been fully maintained; in fact, the conditions are rather better than they were last week, for the reason that the tonnage at the disposal of the collieries is larger and most undertakings are more comfortably situated. At the same time, it cannot be claimed that prices have undergone any appreciable alteration, though, with the possible exception of dry qualities, they can be said to be firm. Collieries in many cases are not, however, selling ahead at present figures. Their ideas for March loading are that better values will be seen, and therefore they are holding their hands. Reference was made last week to the fact that the Paris and Orleans Railway had purchased 150,000 tons of steam coals from this district. These coals are large and smalls, and some of the business is understood to have been carried through on a f.o.b. basis and the remainder on a c.i.f. basis. Delivery is over the next six months, but apart from the business concluded, the railway is inquiring for supplies of washed dry duff for delivery over February, March and April. The fact that the railway has come to this district for supplies has afforded some satisfaction, and the hope is entertained that other French buyers will again turn their attention to South Wales. It cannot be said that the continental inquiry at the moment is active, as most business is confined to the arrangement of single cargoes; yet at the same time there is more activity than appears on the surface, and certainly shipments to foreign coaling stations are brisker. As to what the future has in store for the industry there is no evidence of any great anxiety. There is certainly some speculation as to what the Coal Commission's report will contain, but many hold the optimistic view that a settlement will be come to without any Government action. There appears to be a rather better tone prevailing under the surface, notwithstanding the utterances of the secretary of the Miners' Federation. As to the question of the Government subsidy, the belief is held in many quarters that this will not be entirely withheld at the end of April, but that it will be continued on a diminishing scale and on a different basis.

Coalfield Items.

It is understood that considerable progress has been made with the negotiations for the reopening of the Cambrian Collieries, which have been closed since August, 1924. Negotiations have been proceeding for weeks past on the question of price lists, &c., and these are now coming to a conclusion; but, of course, when the miners' representatives have drawn up what they consider the best conditions obtainable, the sanction of the general body of the workmen has to be secured. The number of workmen thrown out of employment at Clydach Vale through the closing of the collieries is about 3500, but it is understood that about 1000 of them have obtained employment elsewhere. Considerable satisfaction has been caused in the district by the report that preparations are being made for a resumption of work at the Merthyr Vale No. 2 Pit, belonging to Nixon's Navigation Colliery Company, Ltd., which was closed down about fourteen months ago on account of trade depression, thus throwing out of employment about 1200 men. Half of this number have since then been absorbed at the same company's No. 1 Colliery at Merthyr Vale. It will probably be a few weeks before definite arrangements can be made for the re-opening of the No. 2 Colliery, as a considerable amount of preliminary work has to be done. Another matter for satisfaction is that at the Deep Duffryn Colliery, belonging to the same company, at Mountain Ash, a 7ft. seam has been struck. This pit was closed about two years ago, but since then development work has been in progress in the form of sinking operations to the lower seams. The new seam which has now been struck is reported to be of excellent quality.

Tin-plate Pooling Scheme.

The pooling scheme recently decided upon by South Wales manufacturers of tin-plates came into operation on Monday last. It is reported that under this arrangement the various firms pay into the pool £50 per mill, and subsequent withdrawals and payments are based upon a particular output. Manufacturers who exceed their allotted output will pay into the pool 1s. per basic box, and those firms whose production is below the allotted quantity will receive 9d. per box. A committee will control production, and allot the proportion of output to each individual works. The scheme aims at restriction of output and maintenance of prices and the distribution of employment.

Loss to Wales.

The announcement is made that Mr. S. Roy Illingworth, D.Sc., F.I.C., is severing his connection with the South Wales School of Mines, with which he has been connected for about eight years. Dr. Illingworth has done a good deal of research work as head of the Chemistry Department at Treforest, and in recognition of this he was granted the Gold Medal of the South Wales Institute of Engineers, to which body he has submitted a number of valuable papers which have attracted a considerable amount of attention. His experiments have chiefly been with the low-temperature carbonisation of coal. Dr. Illingworth intends taking several weeks' rest.

Current Business.

Operations have been fairly good, but so far as the leading qualities of steam coals are concerned, it is difficult to obtain shipments this month, owing to the colliery commitments being already so heavy. The docks are now well provided with tonnage, and there is a regular outlet for coals. Best Admiralty large are firm at 23s. 6d. to 24s., and second qualities hold steady at 22s. 6d. to 23s. Smalls continue in good demand. Patent fuel shows a slightly improving tone. Anthracite coals are scarce and firm. The shipments to America have speeded up and a very considerable amount of tonnage has been chartered to load this month and next for the Northern Range of ports. The demand for prompt tonnage has been so pressing that rates of freight have advanced from 10s. 6d. recently to 15s., this sharp rise being attributable largely to the fact that homeward business is so bad. The rate of 15s. is, however, exceptional, and was only paid for a spot boat, whereas other tonnage with readiness at the end of this month and March has been chartered at 12s. 6d. per ton.

EDUCATIONAL INTELLIGENCE.

FOURTEEN Entrance Scholarships and Exhibitions are available for award to students entering University College, London, in October, 1926. Three of them are tenable in any of the five College Faculties: Arts, Law, Science, Engineering, and Medical Sciences, or in the School of Architecture. Two of them are tenable in the Faculty of Arts only, one in the Faculty of Science, one in the Faculty of Engineering, one in the Faculty of Laws, three in the Faculty of Medical Sciences, two in the School of Architecture, and one in the School of Librarianship. Most of the Scholarships and Exhibitions are of the value of £40 a year for three years, but the value of any Scholarship or Exhibition may be increased by the grant of a supplementary bursary if the circumstances of the scholar or exhibitioner make such grant necessary. Particulars of all these Scholarships and Exhibitions may be obtained from the Secretary, University College, London.

LAUNCHES AND TRIAL TRIPS.

TJISAROEA, passenger and cargo steamer; built by the Netherland Shipbuilding Company, to the order of the Java-China-Japan line; dimensions, 420ft. by 55ft. by 37ft. Engines, Parson's turbine of 3000 brake horse-power; constructed by Werkspoor, Amsterdam; trial trip, January 15th.

OAKBANK, motor vessel; built by Harland and Wolff, Ltd., to the order of the Bank Line, Ltd.; dimensions, 434ft. by 53ft. 9in. by 37ft.; 5200 gross tonnage. Engines, Harland-B. and W. motors; constructed by the builders; launch, January 18th.

PATRIS II., passenger steamship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of the Byron Steamship Company, Ltd.; dimensions, 335ft. Engines, inverted direct-acting triple-expansion, surface-condensing; constructed by the builders; trial trip, January 19th.

GEORGE L. TORIAN, steamer; built by Earle's Shipbuilding and Engineering Company, Ltd., to the order of the Eastern Steamship Company, Ltd., of Canada; dimensions, 258ft. by 44ft. by 20ft. Engines, triple-expansion, surface condensing, 17in., 28in., 46in. diameter by 33in. stroke, pressure 180 lb.; constructed by the builders; launch, January 20th.

STORSTAD, motor oil tanker; built by the Blythswood Shipbuilding Company, Ltd., to the order of Klaveness Damskibsaktieselskab, Oslo; dimensions, 490ft. by 62ft. 3in. by 35ft.; 9000 gross tonnage. Engines, two sets of six-cylinder, four-stroke cycle, single-acting, Diesel; constructed by J. G. Kincaid and Co., Ltd.; trial trip, January 20th.

AZANIA, steamer; built by Ferguson Brothers (Port-Glasgow), Ltd., to the order of the Crown Agents for the Colonies; dimensions, 150ft. by 29ft. by 11ft. 6in. Engines, twin-screw compound surface-condensing; constructed by the builders; trial trip, January 28th.

ARTHUR W. SEWALL, tank steamer; built by Sir W. G. Armstrong, Whitworth and Co., Ltd., to the order of Ivarans Rederi, of Oslo; dimensions, 360ft. by 50ft. 6in. by 35ft. 3in.; to carry 9200 tons deadweight. Engines, direct-acting, surface-condensing, triple-expansion, 27in., 45in., 75in. diameter by 51in. stroke, pressure 180 lb.; constructed by the builders; launch, January 29th.

NOVA SCOTIA, steamer; built by Vickers Ltd., to the order of the Warren Line (Liverpool), Ltd.; dimensions, 405ft. by 55ft. 3in. by 34ft. 4in.; 5388 gross tonnage. Engines, four-crank inverted, vertical direct-acting, surface-condensing, quadruple-expansion, 31in., 43in., 62in., 90in. diameter by 57in. stroke, pressure 215 lb.; constructed by the builders; launch, January 29th.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

JAMES GORDON AND CO., Ltd., of Windsor House, Kingsway, inform us that Mr. J. J. Lassen has retired from the board of directors of, and has no further interest in, or connection with, the company.

JOHN SPENCER, Ltd., of Wednesbury, asks us to state that it has opened offices at College Hill House, 176–178, Upper Thames-street, London, E.C. 4, under the management of Mr. Philip Spencer, and that this new branch will deal with the sales of all the firm's specialities.

WE are asked to state that the offices of Mr. W. Worby Beaumont and Mr. L. N. Burt have been transferred from Outer Temple, 222, Strand, to 20, Essex-street, Strand, London, W.C. 2. The telephone number, City 7854, and the telegraphic address, "Vibromotor, Estrand, London," remain unchanged.

T. W. BROADBENT, Ltd., electrical manufacturer and contractor, of Victoria Electrical Works, Huddersfield, announces that it has arranged with Messrs. Darroch and Espie, of Dock Works, 37, Weir-street, Paisley-road, Glasgow, to act as its representatives in Scotland, as successors to Mr. James Espie, of the same address, who is retiring from business.

WE are informed by William Jacks and Co. that the private limited liability company of William Jacks and Co., Ltd., trading at Glasgow and elsewhere, having gone into voluntary liquidation, the liquidator has sold the goodwill of this company to them. In future their offices in Glasgow and Middlesbrough will be conducted under the name of William Jacks and Co. instead of William Colvin and Co., as heretofore.

CONTRACTS.

THE PATERSON ENGINEERING COMPANY, Ltd., of Windsor House, Kingsway, London, W.C. 2, is supplying the complete equipment for the twenty-four primary filter units for the Kempton Park Waterworks of the Metropolitan Water Board. The plant, when completed, will have a total capacity of 48,000,000 gallons per day and will, it is believed, be the largest pre-filtration plant in Europe.

CALENDARS, DIARIES, &c.

JOHN FOWLER AND CO. (Leeds), Ltd., Leeds.—Desk calendar with weekly tear-off sheets.

PRIEST FURNACES, Ltd., 123, Albert-road, Middlesbrough—Refill for 1926 for desk frame.

THE CLAY CROSS COMPANY, Ltd., Clay Cross, near Chesterfield.—Diary for 1926.

LE GRAND AND SUTCLIFF AND GELL, Ltd., Southall, London, W.—Wall calendar with change cards for the date.

ANCHOR LINE (HENDERSON BROTHERS), Ltd., 48, Fenchurch-street, E.C. 3.—Wall calendar with weekly tear-off sheets.

A COMBINE IN THE CONTINENTAL WIRE TRADE.—There is now under consideration a project for a working agreement between the wire-drawing, nail-making and tack-making firms of Belgium, Luxemburg and Germany. A conference of the various parties interested was recently held in Brussels, thirteen Belgian delegates, five German delegates and two from Luxemburg attending. The Germans represented the "Drahtverband," a syndicate of wire makers and users formed a short time ago. It was considered that a combination of the kind proposed would dominate the market, and would have nothing to fear from American competition, especially if, as was hoped, the French industry would ally itself with that of the neighbouring countries.

COMPETITION FOR THE DESIGN OF SUBWAYS IN PARIS.—The City of Paris announces that it proposes to institute a competition with a view to the provision of underground passages in the city area for the improvement of traffic facilities. The competition will be open to foreigners, provided that they obtain beforehand permisson of the Administration of the Prefecture of the Seine to take part in it. The value of the prizes placed at the disposition of the jury, which will adjudicate on the proposals submitted, is 100,000f.—or, at the present rate of exchange, about £775. Applications to take part in the competition must be made by March 31st next, after which no application can be entertained. Details of proposed schemes must be deposited at latest by 5 p.m. on June 30th next. Further particulars may be obtained by application to La Direction des Travaux de Paris (Secrétariat), 98, Quai de la Rapée, Paris.

OIL ENGINE AND DYNAMO AT BASINGSTOKE.—Referring to a description in our last issue of a Mirrlees, Bickerton and Day engine coupled to a Newton generator at Basingstoke, we are asked by Newton Dynamo Works, Taunton, to say that the dynamo is of their standard design for large units. It complies strictly to B.E.S.A. 168/23 as well as to a stringent specification issued by the Borough Electrical Engineer, Mr. F. Swarbrick. The field magnet system is a feature of the construction. The yoke, which is of cast iron to ensure stability, is provided with ventilating apertures, so arranged that the temperature rise, with the usual current densities in the armature and field windings, is kept well within the prescribed limits without the use of a fan. The temperature rise under test of the various parts was as follows:—Armature, 56 deg. Fah. rise; commutator, 34 deg. Fah. rise; shunt coils, 58 deg. Fah. rise; interpole, 62 deg. Fah. rise. Duration of test, eight hours; average load, 482 volts, 850 ampères, 250 revolutions per minute. The actual measured efficiencies of the dynamo are:—At full load, 93·5 per cent.; at three-quarter load, 93 per cent.; at half load, 92 per cent.; and at quarter load, 86·5 per cent. The armature has an ordinary parallel winding arranged in slots and secured by hardwood wedges, whilst the plates, or laminations, are in one piece and not built up in sections.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	21/-
(1) Spanish	18/6
(1)N. African	18/6
N.E. Coast—	
Native	—
Foreign (c.i.f.)	21/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	3 17 6	—
No. 1 Foundry	3 19 0 to 4 1 6	
No. 3 Foundry	3 16 6 to 3 19 0	
N.E. Coast—		
Hematite Mixed Nos.	3 18 0	3 18 0
No. 1	3 18 6	3 18 6
Cleveland—		
No. 1	3 12 6	3 13 0
Silicious Iron	3 12 6	3 13 0
No. 3 G.M.B.	3 10 0	3 10 6
No. 4 Foundry	3 9 0	3 9 6
No. 4 Forge	3 8 6	3 9 0
Mottled	3 7 6	3 8 0
White	3 7 6	3 8 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 5 0	—
,, Forge	2 16 0 to 2 17 0	
(3) Derbyshire—		
No. 3 Foundry	3 7 6	-
Forge	3 3 0	—
(3) Lincolnshire—		
No. 3 Foundry	3 8 0	—
No. 4 Forge	3 5 6	—
Basic	3 6 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 10 0 (a), 4 12 6 (b), 4 17 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	11 5 0	—
Best	—	—
N.E. Coast—		
Common Bars	11 0 0	—
Lancs.—		
Crown Bars	11 10 0 to 11 15 0	
Second Quality Bars	10 15 0 to 11 0 0	
Hoops	15 0 0	14 15 0
S. Yorks.—		
Crown Bars	12 10 0	—
Best ,,	13 10 0	—
Hoops	14 10 0	—
Midlands—		
Crown Bars	11 10 0 to 12 0 0	
Marked Bars (Staffs.)	14 0 0	—
Nut and Bolt Bars	10 10 0 to 11 0 0	
Gas Tube Strip	12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	11 0 0	—
Ship Plates, ½in. and up.	7 10 0	—
Sections	7 0 0	—
Steel Sheets, under 3/16in. to ¼in.	9 0 0	—
Sheets (Gal. Cor. 24 B.G.)	—	£17 to £18

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E Coast—		
Ship Plates	7 7 6	—
Angles	7 0 0	—
Boiler Plates	11 10 0	—
Joists	7 0 0	—
Heavy Rails	8 0 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	7 5 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 0 0†	—
Light ,,	8 5 0 to 8 10 0	
Billets	7 10 0 to 9 0 0†	
Manchester—		
Bars (Round)	8 5 0 to 8 10 0	
,, (others)	8 0 0 to 8 5 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	13 15 0	13 10 0
Plates	7 17 6 to 8 5 0	
,, (Lancs. Boiler)	11 10 0	—
Sheffield—		
Siemens Acid Billets	10 10 0	—
Bessemer Billets	11 5 0	—
Hard Basic	8 12 6	—
Intermediate Basic	8 2 6	—
Soft Basic	7 0 0	—
Hoops	12 0 0	—
Soft Wire Rods	9 10 0	—
Midlands—		
Small Rolled Bars	7 17 6 to 8 0 0	
Billets and Sheet Bars	6 2 6 to 6 10 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	16 5 0 to 16 12 6	
Angles	7 2 6 to 7 5 0	
Joists	7 2 6 to 7 5 0	
Tees	8 2 6 to 8 5 0	
Bridge and Tank Plates	7 15 0 to 8 0 0	
Boiler Plates	11 0 0 to 12 0 0	

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	19/3 to 19/9
Block Tin (cash)	£84 10 0
,, (three months)	£79 0 0
Copper (cash)	£9 17 6
,, (three months)	£9 17 6
Spanish Lead (cash)	£3 12 6
,, (three months)	£3 12 6
Spelter (cash)	£6 5 0
,, (three months)	£6 0 0
Manchester—	
Copper, Best Selected Ingots	£5 10 0
,, Electrolytic	£8 15 0
,, Strong Sheets	£9 0 0
,, Tubes (Basis Price)	£0 1 1
Brass Tubes (Basis Price)	£0 1 0
,, Condenser	£0 1 2½
Lead, English	£7 0 0
,, Foreign	£6 0 0
Spelter	£8 0 0

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/1 per lb.	
Ferro Tungsten	1/11 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 0 0	8/-
,, 6 p.c. to 8 p.c. ,,	£22 0 0	7/6
,, 8 p.c. to 10 p.c. ,,	£21 0 0	7/-
,, Specially Refined		
,, Max. 2 p.c. carbon	£40 0 0	14/-
,, ,, 1 p.c. ,,	£49 0 0	17/-
,, ,, 0·70 p.c. carbon	£55 0 0	17/-
,, ,, carbon free	1/5 per lb.	
Metallic Chromium	3/6 per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£12 0 0	scale 5/- per unit
,, ,, 75 p.c.	£21 0 0	scale 6/- per unit
,, Vanadium	15/- per lb.	
,, Molybdenum	6/- per lb	
,, Titanium (carbon free)	1/- per lb.	
Nickel (per ton)	£172 to £175	
Cobalt	10/- per lb.	
Aluminium (per ton)	£120	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	17/-
,, ,, Ell	17/9
,, ,, Splint	20/6 to 23/-
,, ,, Trebles	17/-
,, ,, Doubles	16/3
,, ,, Singles	14/-
Ayrshire—	
(f.o.b. Ports)—Steam	17/-
,, ,, Jewel	18/6
,, ,, Trebles	17/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	14/- to 17/-
Screened Navigation	21/6
Trebles	18/6 to 19/6
Doubles	16/-
Singles	14/-
Lothians—	
(f.o.b. Leith)—Best Steam	15/3
Secondary Steam	14/10½
Trebles	17/-
Doubles	16/3
Singles	14/-

ENGLAND.

	Inland.	Export.
(8) N.W. Coast—		
Steams		24/6
Household		40/- to 45/-
Coke		27/-
Northumberland—		
Best Steams		16/6
Second Steams		15/6
Steam Smalls		9/9 to 10/-
Unscreened		14/-
Household		20/- to 22/-
Durham—		
Best Gas		17/- to 17/6
Second		16/3 to 16/6
Household		20/- to 22/-
Foundry Coke		19/- to 21/-
Sheffield—		
Best Hand-picked Branch	31/- to 34/-	
Barnsley Best Silkstone	28/- to 30/-	—
Derbyshire Best Brights	26/- to 28/-	—
,, ,, House	24/- to 25/-	—
,, ,, Large Nuts	17/- to 20/-	—
,, ,, Small	12/6 to 14/-	—
Yorkshire Hards	17/- to 19/6	—
Derbyshire ,,	16/- to 19/-	—
Rough Slacks	10/- to 12/6	—
Nutty ,,	7/6 to 9/-	—
Smalls	3/6 to 6/-	—
Blast-furnace Coke (Inland)*	—	—
,, ,, (Export)	f.o b.	19/- to 20/-

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	23/6 to 24/-
Second ,, ,,	22/- to 23/-
Best Dry Large	21/6 to 22/6
Ordinary Dry Large	20/- to 21/-
Best Black Vein Large	21/- to 21/6
Western Valley Large	20/- to 20/6
Best Eastern Valley Large	20/- to 20/6
Ordinary ,, ,,	19/- to 20/-
Best Steam Smalls	13/6 to 14/-
Ordinary ,,	11/- to 13/-
Washed Nuts	19/- to 20/-
No. 3 Rhondda Large	27/- to 27/6
,, ,, Smalls	17/- to 18/-
No. 2 ,, Large	19/6 to 20/6
,, ,, Through	16/6 to 17/6
,, ,, Smalls	10/6 to 11/-
Foundry Coke (export)	37/6 to 40/-
Furnace Coke (export)	25/- to 30/-
Patent Fuel	20/- to 22/6
Pitwood (ex ship)	25/6 to 26/-
Swansea—	
Anthracite Coals:	
Best Big Vein Large	41/6 to 42/6
Seconds	33/- to 35/-
Red Vein	27/- to 30/-
Machine-made Cobbles	52/6 to 55/-
Nuts	55/- to 57/6
Beans	42/6 to 45/-
Peas	21/- to 24/-
Breaker Duff	7/9 to 8/3
Rubbly Culm	9/- to 9/6
Steam Coals:	
Large	22/- to 23/6
Seconds	20/- to 22/-
Smalls	9/- to 10/-
Cargo Through	16/6 to 18/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 17/-, with fluctuations according to analysis; open market, 17/6 to 19/- at ovens. † Latest quotations available. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

Continuous Brakes.

THE equipment of goods trains with continuous brakes is becoming a matter of extreme urgency, because it is obvious that goods traffic must be considerably accelerated if economies are to be realised, alike by the railway companies and by users, and also because the supplying of brake equipments would afford employment to manufacturers of railway material, who are at present destitute of work. When some months ago the Government was reported to have decided upon ordering brake equipments from Germany on account of reparations, the proposal met with so much opposition that it had to be abandoned, and since then there have been persistent efforts to counteract the success of the Kunze-Knorr brake, which has been adopted almost generally throughout Central Europe, despite the attempts of France and some other countries to impose the Westinghouse brake. This latter apparatus has, it is understood, had to undergo some modifications to adapt it for use with goods trains, and is not even yet entirely beyond the experimental stage, so far as the European railways are concerned, for further trials are to be carried out in Italy in conjunction with the Kunze-Knorr and other brakes. Nevertheless, it is regarded as quite satisfactory, and has received definite French approval. The trouble now is that it is extremely difficult to set off another brake against the Kunze-Knorr, which is fitted on all the goods wagons in Germany and is likely to be adopted in adjoining countries. So firm is the hold taken by the Kunze-Knorr brake in Central Europe that it is reported to have been officially accepted by the International Commission. The French declare that the Germans have imposed their brake in defiance of treaties, but those treaties only provided that the brake should be interchangeable with others approved of by the Berne Convention, and if, as is stated, the Kunze-Knorr has received official acceptance, it will mean that trucks fitted with otner brakes will have to be coupled up with the German wagons. Whether the K.K. brake has been officially accepted or not, it appears impossible to deprive it of the success it has acquired in Germany and elsewhere, and it is even further stated that the Westinghouse Company is taking the precaution to arrange for the manufacture and equipment of the K.K. brakes in France. So far as the French manufacturers are concerned, it is quite immaterial to them what type of brake is adopted, but they object to the equipments for the French railways being supplied by German firms, and they insist on the work being kept in the country. As the State is unable to provide the huge sum of money needed for fitting all the goods wagons with continuous brakes, the funds could probably be supplied by the financial group which was constituted in 1924 for the purpose, and was unable to proceed further pending the selection of an acceptable system of brake.

Motor Cars.

The motor car industry is beginning to feel the pinch of the changes that are taking place in the economic situation. So long as the franc was declining at a much more rapid rate than the cost of commodities was rising, the demand for cars for export steadily increased, and the home requirements were also satisfactory, but the sudden cessation of activity, due to the reserved attitude of buyers, who are beginning to see the situation in its true light, has proved extremely embarrassing for many firms. Costs are advancing at a disquieting rate, and some makers find that they are unable to deliver goods without loss, because they have to pay much more for their raw material. There is consequently a certain amount of reorganisation taking place, principally in the way of a mass production of a smaller number of new models, and with a view of specialising on one type, it is reported that a leading motor car firm is seeking the aid of American capital. Mr. Morris, of Morris-Cowley fame, is also putting on the French market a new model from the Bollée works at Le Mans, which he acquired some time ago. While in France the tendency is in the direction of specialising in one or two models, a similar departure seems to be taking place in Germany, where the failure of a French group to secure the bankrupt A.G.A. concern, in which the Stinnes family is interested, has been followed by the announcement of a possible combination amongst a number of German motor car firms to turn out one type of car on economic lines, each specialising in different parts, and one works will be engaged exclusively on the erection of the chassis.

Concrete Piling.

Pile foundations are employed very extensively in Paris on account of the considerable depth of alluvial soil on each side of the river, and for purposes of economy various systems of piles are used to replace wood piles, the cost of which has become almost prohibitive. Concrete piles are prepared on the site where they are to be driven in. One form is to take ¾in. rods having the length of the pile. About half a dozen rods are arranged on a frame to form a cylinder and are held by wire or hoops. The shuttering gives to the concrete pile a hexagonal section. Such piles are being used in places where there is a great depth of water-logged soil. The same principle of construction is also employed in the buildings themselves to replace joists and girders, and preference seems to be fairly equally divided between reinforced concrete and steel sections. For constructional purposes generally, concrete is being employed on an increasingly large scale.

Iron and Steel Production.

As is the case generally with the metallurgical industries in the northern departments, where the capacity of production was largely increased by the reconstruction of works with modern installations, the blast-furnaces are producing far more than they did before the war. On January 1st last there were 147 furnaces in blast, 29 were ready to be put in operation and 43 were under repairs. The total production of pig iron in 1925 was 8,471,800 tons, as against 7,651,972 tons in 1924 and 5,207,000 tons in 1913. Raw steel totalled 7,415,072 tons, as compared with 6,906,502 tons in 1924, and 4,687,000 tons in 1913.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

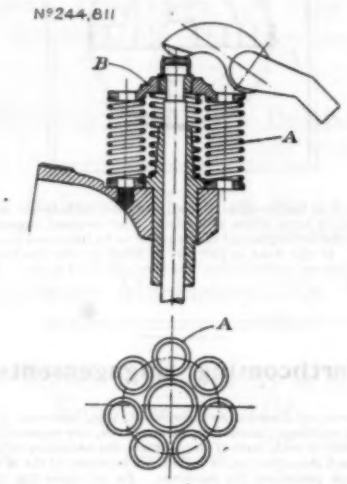
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

244,811. June 2nd, 1925.—SPRING-OPERATED VALVE FOR INTERNAL COMBUSTION ENGINES, John Alfred Prestwich, of Rosecrath, Woodside-avenue, Muswell Hill, London, N. 10.

This invention relates to spring-operated valves on internal combustion engines. The load is distributed over a number of

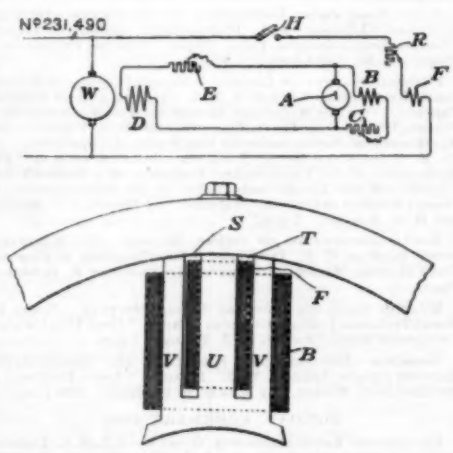


springs A, which are therefore subjected to moderate stresses only, and their life is considerably lengthened. Moreover, a broken circumferential spring can easily be removed and a fresh one inserted without removing the head plate B.—*December 31st, 1925.*

DYNAMOS AND MOTORS.

231,490. March 24th, 1925.—IMPROVEMENTS IN AND RELATING TO VOLTAGE REGULATION OF EXCITERS, *The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C. 2.*

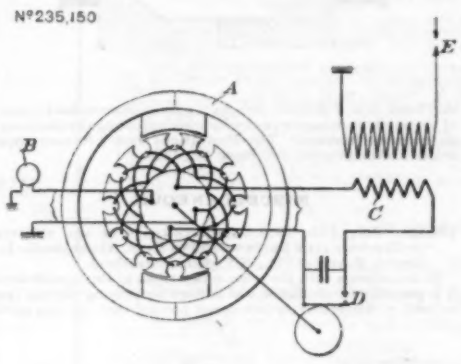
It is frequently necessary to operate a dynamo-electric machine at voltages which must be regulated over a very considerable range. Thus, in the case of exciters, for example, it not infrequently happens that the voltage must be varied from 100 volts as a minimum to 200 or 250 volts as a maximum. It is customary to produce these variations by means of an exciter field rheostat through the adjustment of which the value of the exciter field flux is controlled. This method of control is satisfactory at the higher voltages when the iron portions of the magnetic circuit are operated at a flux density above the knee of the saturation curve, but at the lower flux densities it is unreliable, owing to the fact that very slight adjustments of the rheostat are apt to produce abnormal changes in the flux and voltage of the exciter. In accordance with this invention, this



difficulty is avoided by providing parallel sections in the iron portions of the magnetic circuit and surrounding certain of these sections with bucking coils energised from the armature of the machine to be excited, and arranged to maintain the flux density required for stable control during low voltage operation of the machine. The exciter A is provided with a main field winding B and a field rheostat C, which are connected in series across the brushes of the exciter. D is a field winding of a generator W. A rheostat E may be provided in the generator field circuit if it is desired to control the generator voltage independently of the exciter voltage. For the purpose of regulating the exciter voltage, a bucking coil F is connected to the generator brushes and in series with a switch H and rheostat R. The lower illustration is a section through one pole of the exciter. The integral pole cores of the exciter are provided with slots S and T cut in from the yoke end of the core. The bucking coil F of each pole is placed in the slots S and T, and is wound to produce a flux opposed to that produced by the main winding B which surrounds the entire core. If the exciter is to have a range of 250 to 100 volts, the coils F should be wound for approximately 100 volts. Assuming that the coils F are arranged to maintain between the ends of the section U a magnetomotive force as great as that maintained across this section by the main coil B, there will be no resultant magnetomotive force across this section. Under these conditions the section U will carry no flux although the flux density of the sections V may be high. It is thus possible to shunt the useful flux through the sections V, which are consequently maintained at a flux density sufficiently high to ensure stable operation of the exciter at low voltages. The flux density in these sections may be further increased by increasing the ampère turns of the coils F, which will then produce a flux superimposed on the useful flux of the machine. The bucking coils are, of course, utilised only when the exciter is to be operated at the lower voltages. The method of operating the machine is fully described.—*January 7th, 1926.*

235,150. April 14th, 1925.—ELECTRIC MACHINE WITH ROTATING MAGNETS, Société d'Applications et de Fabrications Industrielles, Safi, of 14, Rue de Bassano, Paris (Seine).

This specification describes an electric generator suitable for use on a vehicle such as a motor cycle or motor car.



The bi-polar field system A revolves and generates two-phase current in the armature. One of the phases supplies a lighting circuit B, whilst the other phase energises the primary circuit C of an ignition coil. This circuit is made and broken at D, and the spark is produced in the secondary circuit at E.—*January 7th, 1926.*

ELECTRICAL APPLIANCES.

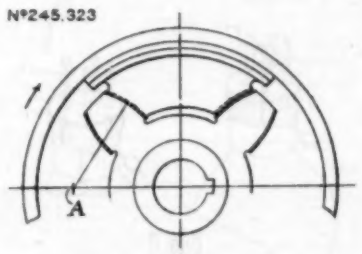
241,209. October 8th, 1925.—IMPROVEMENTS IN OR RELATING TO ALTERNATING-CURRENT RECTIFYING INSTALLATIONS, *International General Electric Company, Incorporated, of 120, Broadway, New York, United States of America.*

Rectifiers, such as mercury vapour rectifiers, which have been out of use for a long time, and more particularly in a cold building, have a tendency to back-fire. A rectifier which is not in use does not therefore constitute a real reserve or stand-by for one which is working. On the contrary, it is often necessary, before starting, carefully to heat the rectifier by means of current of low voltage. This can, however, be avoided by keeping the rectifier constantly warm. According to this invention, the pipe for the cooling medium is arranged in such a manner that the escaping heated cooling medium of the rectifiers which are working can be passed through one or more rectifiers which are not in use. This guiding of the cooling medium is preferably arranged so that it can be changed over by means of cocks or valves and one or the other of the rectifiers can be placed in use at will. The heated cooling medium can escape directly from each rectifier in the usual manner without passing through another rectifier, as, for instance, when the latter is being repaired or when both rectifiers are to be used simultaneously.—*December 31st, 1925.*

TRANSMISSION OF POWER.

245,323. April 8th, 1925.—CENTRIFUGAL FRICTION CLUTCHES, David Brown and Sons (Huddersfield), Ltd., Huddersfield, and H. E. Merritt.

This invention relates to centrifugal clutches of the type in which the torque is transmitted by virtue of the frictional forces induced by centrifugal force between a series of shoes, carried in peripheral recesses in a "spider" secured to the driving shaft, and the inner surface of a drum secured to the driven shaft.



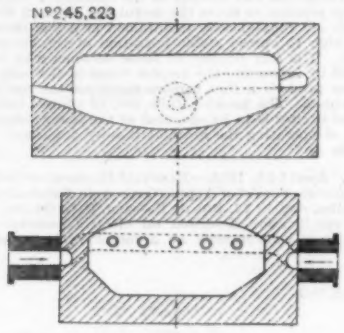
The shoe, it will be seen, is symmetrical, so that it can work either way, and is provided with curved end faces, which co-act with the curved faces of the spider arms. The curvature is such that the centre of rotation of the shoe is at A, on a line at right angles to its radial centre line. The result is that the shoes are free to accommodate wear, while the reaction of the spider tends to assist centrifugal force in making the clutch grip.—*January 7th, 1926.*

METALLURGY.

245,223. October 13th, 1924.—DIRECT PRODUCTION OF IRON AND STEEL, R. H. M. L. Tournié, 13, Boulevard Malesherbes, Paris.

The inventor claims:—"A process for the direct production of iron and steel from washed or unwashed ores, which consists in introducing the ore, together with the necessary fluxes, and, if desired, carbonaceous substances, into a tilting furnace, melting said ore in an oxidising atmosphere by the combustion of coke-oven gas, water gas, heavy oil vapours or like carbon-containing gases or vapours for the purpose of burning off the harmful constituents of said ore, periodically removing from said furnace the slag floating on the resulting molten bath in such a way that a bath of molten iron oxide containing reduced iron—which falls to the bottom—is ultimately produced, thereupon

continuing the heating in a reducing atmosphere in such a way that the unburnt reducing gas acts on the surface of the molten oxide bath to reduce same to metal, which falls to the bottom of

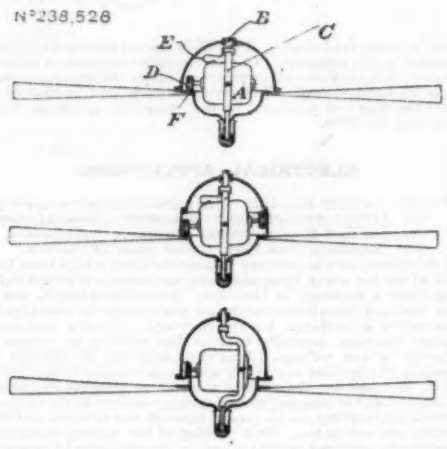


said bath, and, if desired, carburising the molten metal by means of the unburnt reducing gas by suitably adjusting the duration of the reducing heating." The illustrations show a furnace appropriate for the process.—*January 7th*, 1926.

MISCELLANEOUS.

238,528. July 20th, 1925.—IMPROVEMENTS IN AND RELATING TO ELECTRICALLY DRIVEN CEILING FANS, Aktiengesellschaft Brown, Boveri et Cie., of Baden, Switzerland.

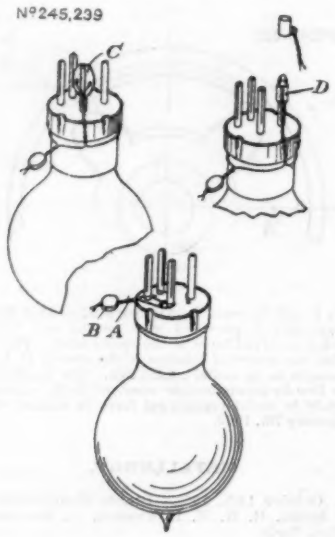
In accordance with the scheme described in this specification, it is possible to use high-speed motors for driving electric fans, instead of the relatively low-speed motors that are commonly



employed. In the example shown in the upper illustration, the motor A is suspended from the fan shaft B in a U-shaped stirrup C. The pinion D is pressed by means of a spring E against a wheel track F, which carries the fan blades. The other arrangements are self-explanatory. Two other schemes are also illustrated.—*January 7th*, 1926.

245,239. November 6th, 1924.—IMPROVEMENTS IN THERMIONIC VALVES, Radions, Ltd., of Radion Works, Bollington, Chester, and Henry James Osborn, of the same address.

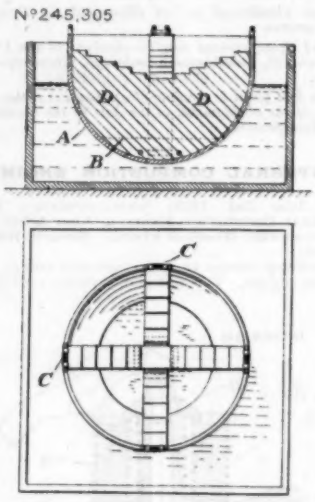
In order to prevent the use of thermionic valves before they are sold to the public, the inventors provide valves with arrangements which prevent the pins being inserted in the valve holder sockets without first breaking a seal. Several arrangements are shown in the accompanying illustrations, which are



practically self-explanatory. In the case of the lower illustration, two or more of the contact pins of the valve are connected together by a wire A, which is wound one or more times round the terminals, and sealed by a lead or other seal B, so that two of the pins are short-circuited. In the case of the scheme shown in the upper left-hand illustration, a thin disc of metal C fits into one of the slits in a valve pin, whilst in the case of the arrangement shown in the upper right-hand illustration a cap D fits over one of the valve pins.—*January 7th*, 1926.

245,305. February 21st, 1925.—APPARATUS FOR BALANCING BODIES, The English Electric Company, Ltd., W. E. M. Ayres, and E. H. H. Hassler, 22, Kingsway, London, W.C. 2.

The inventors propose to test a body, such as the rotor ring of a turbine, for balance by means of loading them on to a float.



The float A is ballasted at B and provided with spirit levels C C for setting it level when unloaded. The stepped supports D D facilitate the arrangement of the piece to be balanced in a central position. If the float is put out of level by the loading of the job, weights are added until it is brought level again.—*January 7th*, 1926.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

BOROUGH POLYTECHNIC INSTITUTE.—Borough-road, London, S.E. 1. Annual prize distribution. 7.30 p.m.

DEPARTMENT OF CHEMICAL ENGINEERING.—University College, Gower-street, London, W.C. 1. Public lecture, "The Theory of Fine Grinding," by Dr. Geoffrey Martin. 5 p.m.

INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Applied Science Department of the University, St. George's-square, Sheffield. Paper, "Drop Forgings," by Dr. O. F. Hudson. 7.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "The Application of Special Cast Irons in the Engineering Industry," by Mr. S. E. Dawson. 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Informal meeting. Discussion on "Refrigerating Machinery," introduced by Mr. G. C. Hodson. 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS: YORKSHIRE BRANCH.—Hotel Metropole, Leeds. Paper, "The Choice of Steels for Engineering Work," by Mr. A. P. Hague. 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Honorary members' lecture, "A Visit to some Power Stations in the U.S.A. in 1925," by Mr. W. H. Patchell. 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society's Lecture Theatre, Newcastle-upon-Tyne. Paper, "Electric Propulsion of Ships," by Mr. Eskil Berg. 7.30 p.m.

PHYSICAL SOCIETY OF LONDON.—Imperial College of Science, South Kensington, London, S.W. 7. Annual general meeting. Papers:—"On the Hyperbola Method for the Measurement of Surface Tension," by Dr. A. Ferguson and Mr. I. Vogel: "The Application of Radiography to the Study of Capillarity," by Dr. E. A. Owen and Mr. A. F. Dufton; demonstration of "The Application of the Piezo-electric Properties of a Rochelle Salt Crystal and the Tri-electrode Valve to the Determination of Impact Stresses in Granular Material," by Messrs. J. J. Hartley and R. H. Rinaldi. 5 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "The Chemistry of Blue and Red Colouring Matters of Flowers," by Professor R. Robinson. 9 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE.—Room 24, Royal Technical College, Glasgow. Paper, "Grey Iron Castings for Special Needs," by Mr. H. J. Young. 7 p.m.

WOMEN'S ENGINEERING SOCIETY.—26, George-street, Hanover-square, London, W. 1. Lecture, "Some Problems of the Machinery Market," by Miss E. M. Kennedy. 6.30 p.m.

MONDAY, FEBRUARY 15TH.

ELECTRICAL ASSOCIATION FOR WOMEN.—E.L.M.A. Lighting Service Bureau, 15, Savoy-street, London, W.C. 2. Lecture, "Electric Light in the Home," by Mr. W. E. Bush and Miss Hodge. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: SCOTTISH CENTRE.—Royal Technical College, Glasgow. Paper, "Modern Chassis-frame Design and Body Mounting," by Mr. T. D. Carpenter. 7.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. Cantor Lecture, "The Production and Measurement of High Vacua, I.," by Dr. G. W. C. Kaye. 8 p.m.

TUESDAY, FEBRUARY 16TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Broadgate Café, Coventry. Coventry Graduates' meeting. Paper, "Weight Reduction," by Mr. A. E. L. Collins. 7.15 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—Visit to the works of Davis and Timmins, Ltd., Wood Green, London, N. 2.15 p.m.

STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Girls' High School, Dudley. Discussion on "Wrought Iron *v.* Steel." 7 p.m.

WEDNESDAY, FEBRUARY 17TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Chamber of Commerce, New-street, Birmingham. Birmingham Graduates' meeting. Paper, "Weight Reduction," by Mr. A. E. L. Collins. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: WOLVERHAMPTON CENTRE.—Engineering and Scientific Club, Queen-street, Wolverhampton. Paper, "The Preparation of Motor Cycles for Speed Events," by Mr. P. Brewster. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, London, S.W. 1. Students' meeting. Paper, "Sub-aqueous Tunnelling in Compressed Air, with reference to Barking Power Station Cable Tunnel under the River Thames," by Mr. D. S. Matheson. 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND CENTRE.—The University, Edmund-street, Birmingham. Paper, "The Electrification of the Paris–Orleans Railway," by Monsieur H. Parodi. 7 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "The Propagation of Electric Waves," by Mr. J. E. Taylor. 8 p.m.

SCHOOL OF ENGINEERING (POPLAR) OLD BOYS' SOCIETY.—High-street, Poplar, London, E. 14. Paper, "Present-day Development in the Electrical Supply Industry," by Mr. O. L. Robson. 7.45 p.m.

THURSDAY, FEBRUARY 18TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Watergate House, Adelphi, London, W.C. 2. London Graduates' meeting. Paper, "Practical Notes on Turning and Shop Practice," by Mr. J. Gilson. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Hotel Metropole, Leeds. Lecture, "The Methods of Survey and Setting-out for Tunnel Work, with Special Reference to Sewers," by Mr. J. Clemishaw. 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Paper, "The Electrification of the Paris-Orleans Railway," by Monsieur H. Parodi. 6 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS: YORKSHIRE BRANCH.—Great Northern Hotel, Leeds. Paper, "Transverse Bracing of Bridges," by Professor J. Husband. 6.30 p.m.

FRIDAY, FEBRUARY 19TH.

DIESEL ENGINE USERS' ASSOCIATION.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Heavy Oil Engine Installations: Choice of Site and Lay-out of Plant," by Mr. Geoffrey Porter. 3.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Queen's Hotel, Coventry. Coventry Graduates' annual dinner. 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—The Engineers' Club, Coventry-street, London, W. 1. Annual dinner. 6.30 for 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate Westminster, London, S.W. 1. Annual general meeting. Paper, "The Measurement of Cutting Temperatures," by Mr. E. G. Herbert. 6 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—The Council House, Birmingham. West Midland District meeting. Paper, "Concrete in Modern Road Construction," by Mr. H. V. Overfield. 5.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Paper, "Coal-cutting Machinery," by Mr. S. Reilly. 7.30 p.m.

RAILWAY CLUB.—65, Belgrave-road, London, S.W. 1. Annual general meeting, followed by presidential address. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "George III. in his Papers," by Hon. J. W. Fortescue.

WEST BROMWICH ENGINEERING SOCIETY.—Technical School, West Bromwich. Lecture, "The Development of Electricity," by Professor W. Cramp. 7.30 p.m.

SATURDAY, FEBRUARY 20TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Florence Restaurant, Rupert-street, London, W. 1. London Graduates' annual dinner and dance. 6.45 p.m.

STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Dudley Arms Hotel, Dudley. Annual dinner. 6 p.m.

MONDAY, FEBRUARY 22ND.

INSTITUTION OF STRUCTURAL ENGINEERS: MIDLAND COUNTIES BRANCH.—Chamber of Commerce, Birmingham. Paper, "Arterial Road Construction," by Mr. H. F. Lea. 7.30 p.m.

RAILWAY CLUB.—65, Belgrave-road, London, S.W. 1. Paper, "Development of the Railway Carriage," by Mr. B. M. Bazley. 8.15 p.m.

TUESDAY, FEBRUARY 23RD.

INSTITUTE OF MARINE ENGINEERS.—85–88, The Minories, Tower Hill, London, E. 1. "The Principles and Practice of Automatic Steering," by Mr. F. S. Clifford. 6.30 p.m.

WEDNESDAY, FEBRUARY 24TH.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "Domestic Heating," by Dr. Margaret Fishenden. 8 p.m.

ROYAL MICROSCOPICAL SOCIETY.—20, Hanover-square, London, W. 1. Paper, "The Application of the Microscope to the Examination of Pigments and Paints," by Mr. C. A. Klein. 7.30 p.m.

THURSDAY, FEBRUARY 25TH.

ENGINEERING GOLFING SOCIETY.—Institution of Civil Engineers, Great George-street, Westminster, S.W. 1. Annual general meeting. 12 noon.

FRIDAY, FEBRUARY 26TH.

CHADWICK PUBLIC LECTURE.—Institution of Civil Engineers' Great George-street, London, S.W. 1. "The Activated Sludge Process of Sewage Treatment," by Dr. H. T. Calvert. 8 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Lecture, "Seven Thousand Years of Shipping," by Mr. J. F. Petree. 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society's Lecture Theatre, Newcastle-upon-Tyne. Paper, "Hydro-mechanical Gearing," by Mr. James Richardson. 7.30 p.m.

MONDAY, MARCH 1ST.

INSTITUTE OF TRANSPORT.—Institution of Electrical Engineers, Savoy-place, Victoria Embankment, London, W.C. 2. Paper, "State Ownership of Waterways," by Mr. H. D. Dickinson. 5.30 p.m.